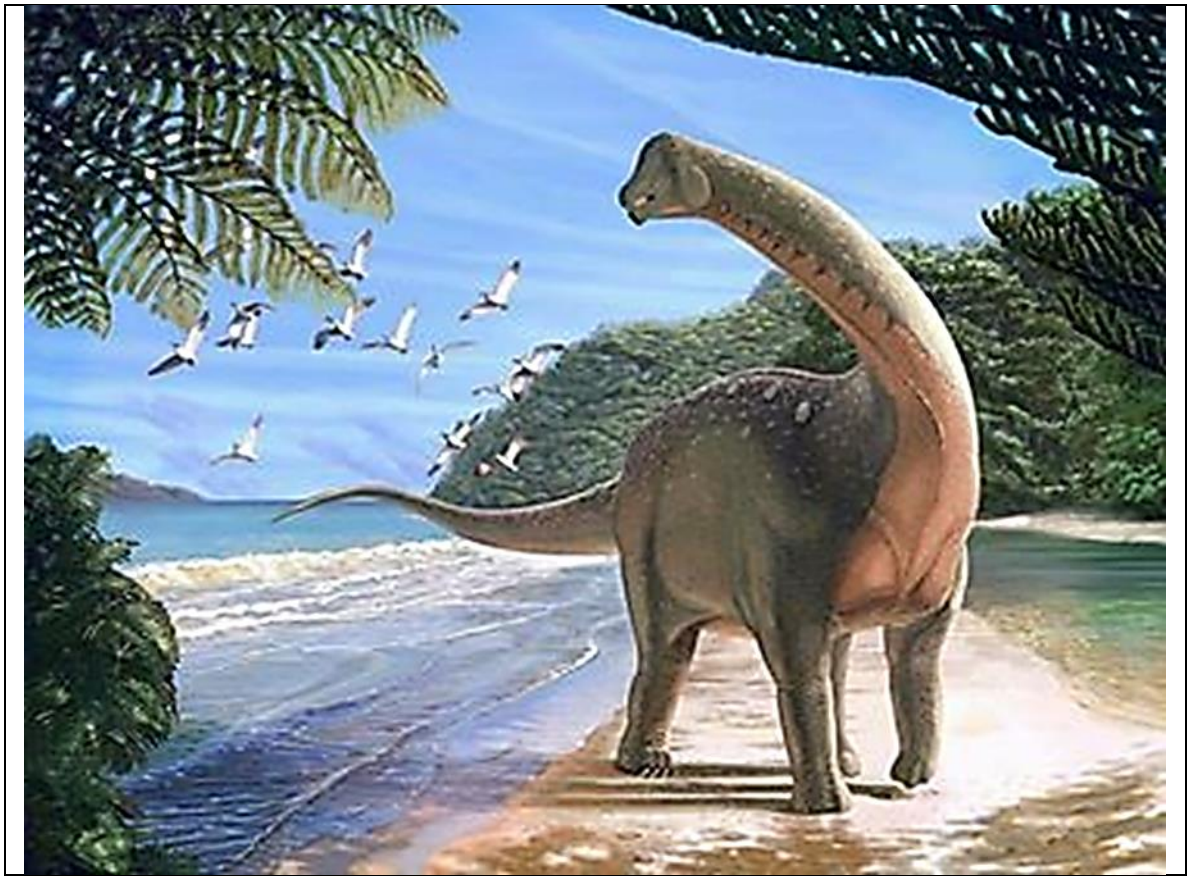
GIT Imaging



Compiled by;

Dr. M. Samy, MD

List of Contents:

❖ Gastro-intestinal Tract

- Esophagus
- Stomach
- Duodenum
- Small intestine
- Large intestine
- Appendix
- Rectum and Anal canal

❖ Peritoneum and Mesentery

- Mesentery
- Peritoneum

❖ Pelvic floor

❖ Acute abdomen

- Trauma
- GIT Bleeding
- Hernia
- Intestinal obstruction
- Intussusception
- Strangulation
- Volvulus

Sources:
Diagnostic imaging of chest
Primer of diagnostic imaging
Radiopedia
Core Radiology
Radiology assistant
Radiographic journal

Esophagus

Esophagus Anatomy

- Length : 23-37 cm
- Diameter: 1-2 cm

❖ **3 Parts:**

- **Cervical:** continuous with the hypopharynx, commences at the lower border of cricoid cartilage (at level of C5/6) or cricopharyngeus muscle
- **Thoracic:** from superior thoracic aperture (T1) => oesophageal hiatus (T10) in the diaphragm
- **Abdominal:** from oesophageal hiatus => Gastro-oesophageal junction

❖ **2 Sphincters:**

- **Upper oesophageal sphincter:** formed by cricopharyngeus muscle at C5/6
- **Lower oesophageal sphincter**, also known as the phrenic ampulla or the oesophageal vestibule: represents 2-4 cm long dilatation between the A-ring and B-ring.

❖ **3 Normal oesophageal constrictions:**

- Cervical constriction: due to cricoid cartilage at the level of C5/6
- Thoracic constriction: due to aortic arch at the level of T4/5
- Abdominal constriction: at oesophageal hiatus at T10/11

❖ **Histological layers:**

- Mucosa
  - Upper esophagus => Stratified squamous epithelium
  - Lower oesophagus => Columnar epithelium
- Muscularis mucosae
- Submucosa
- Muscularis propria
  - Inner circular layer
  - Outer longitudinal layer:
    - Upper 1/3 striated muscle
    - Middle 1/3 striated and smooth muscle
    - Lower 1/3 smooth muscle
- No serosa

❖ **Arterial supply**

- Upper third: inferior thyroid artery
- Middle third: oesophageal branches of the thoracic aorta
- Lower third: oesophageal branches of the left gastric artery

❖ **Venous drainage**

- Upper third: inferior thyroid veins to brachiocephalic veins
- Middle third: azygos vein to svc
- Lower third: left gastric vein to portal vein (site of portal-systemic collateral pathway)

❖ **Lymphatic drainage: Follows arterial supply:**

- Upper third: deep cervical lymph nodes
- Middle third: posterior mediastinal lymph nodes
- Lower third: left gastric and coeliac group lymph nodes

❖ **Normal Esophageal Peristalsis:**

- **Primary contraction:** Propels bolus through the esophagus
- **Secondary contraction**: Follows primary contraction and propels any remaining bolus from thoracic esophagus

❖ **Lower Esophageal Rings**

A-Ring

- Muscular contraction at the junction of tubular and vestibular esophagus
- No definite anatomic correlate

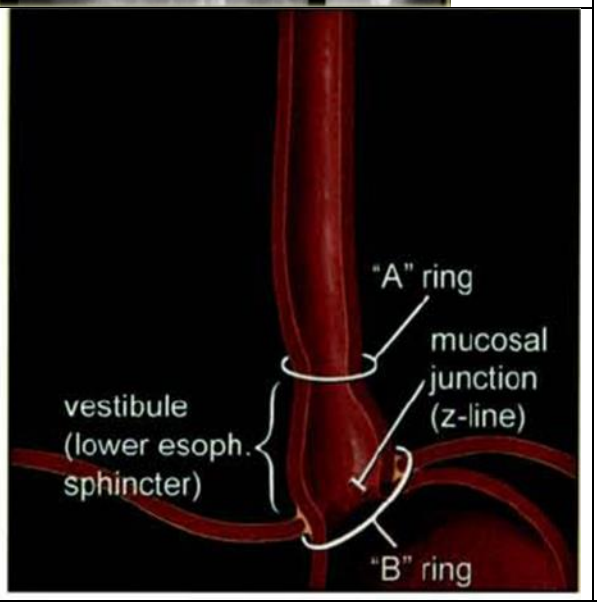
B-Ring

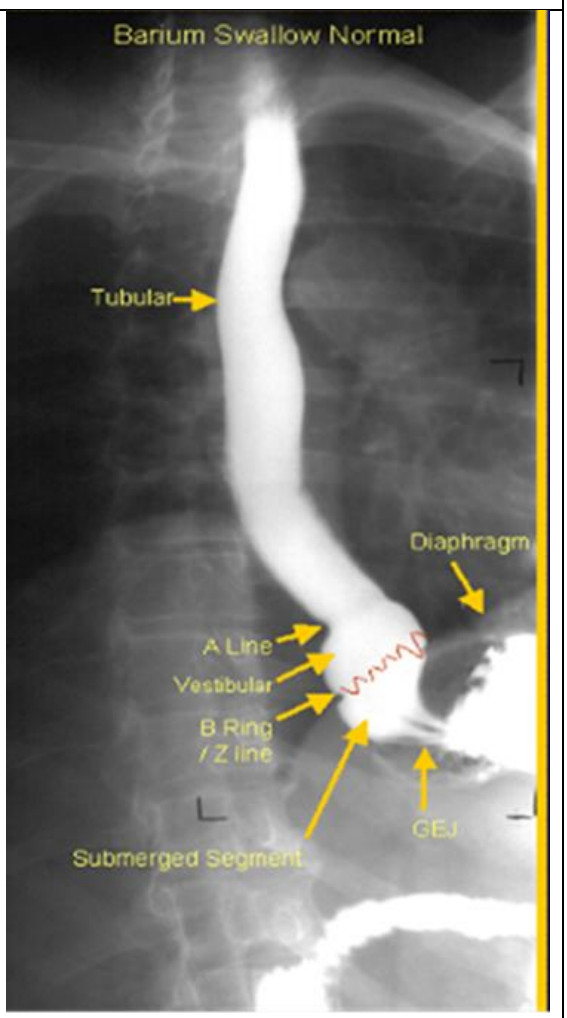
- Mucosal ring at anatomic squamocolumnar junction (Z-line)
- Best or only seen with vestibular distension
- Normally
- May cause episodic dysphagia if esophagus is narrowed, then termed a **Schatzki ring:**
  - 20 mm wide, no obstruction
  - 13-20 mm wide, may obstruct
  - < 13 mm wide, almost always intermittent obstruction

❖ Imaging Modalities:

- **Barium swallow**
- **Endoscopic ultrasonography**
- **CT**
- **MRI**
- **PET/CT**

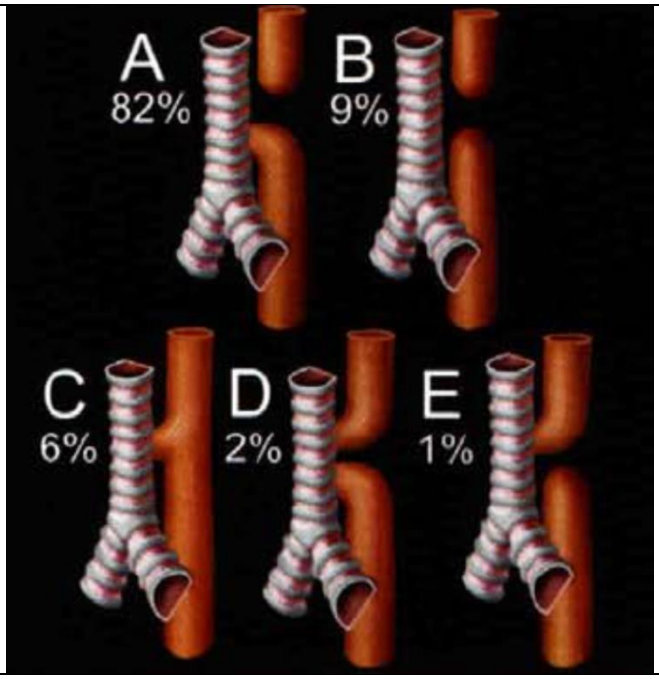
Esophagus mucosa: normal thin, parallel, uniform mucosal fold





Esophageal Atresia (EA) and

Tracheo-Esophageal Fistula (TEF)



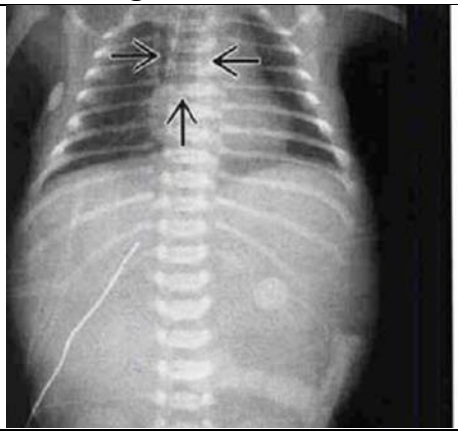
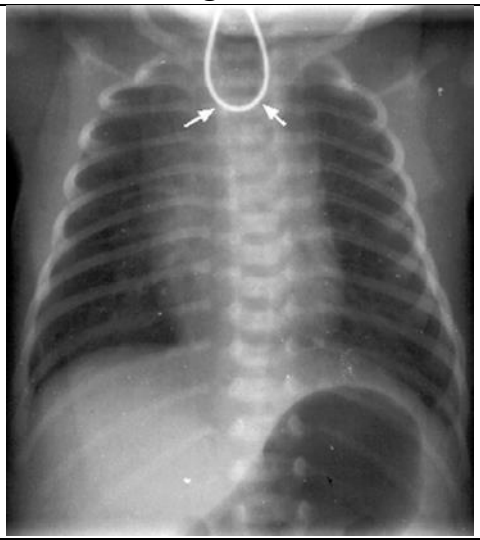
- ✓ **EA with distal TEF 82%**
- ✓ **EA with no TEF 9%**
- ✓ **H- shaped fistula 6%**
- ✓ **EA with proximal and distal TEF 2%**
- ✓ **EA with proximal TEF 1%**

Clinical Presentation:

- Excessive oral and pharyngeal secretions
- Choking, cyanosis, or coughing during first attempt at feeding.
- Recurrent pneumonia

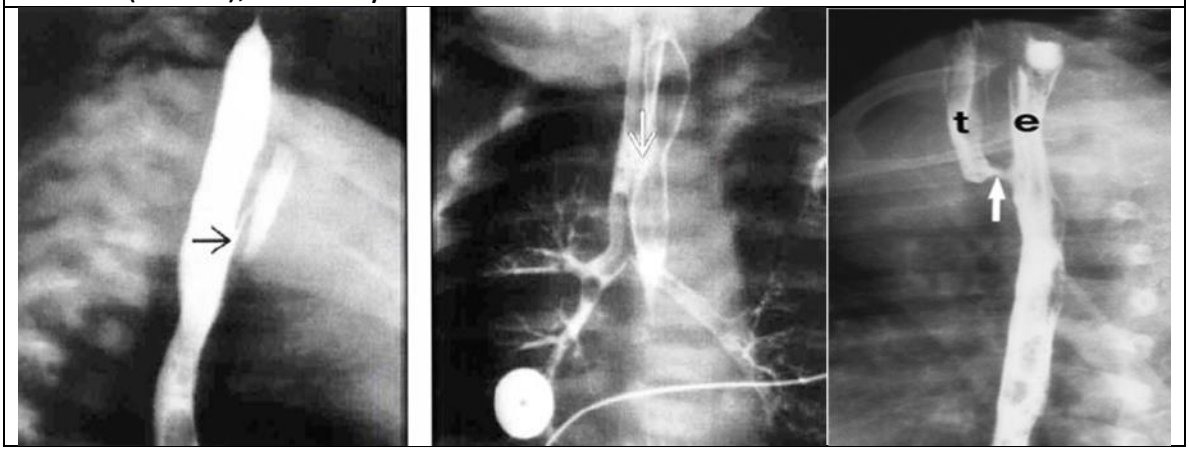
Associations:

- Increased incidence of TEF with Down Syndrome
- About 30% :- born prematurely
- VACTERL=vertebral, anal atresia, cardiac abnormalities, TEF and/or esophageal atresia, Renal agenesis and dysplasia and limb defects

Esophageal atresia and no distal TEF	Esophageal atresia and distal TEF
Enteric tube in upper esophageal pouch (arrows)	Enteric tube tip in proximal esophageal pouch.
No distal bowel gas.	Distal bowel gas.
	
Esophageal atresia and distal TEF	
Oral contrast filling proximal esophageal pouch. Distal bowel gas	Enteric tube tip in proximal esophageal pouch. Distal bowel gas.
	

H-type TEF

Contrast in the esophagus and tracheobronchial tree
Fistula (arrow), mid way between the thoracic inlet and carina.



Congenital Esophageal Stenosis

Congenital esophageal stenosis is a rare developmental anomaly that occurs in about one in 25,000–50,000 live births.

3 Forms

- Tracheobronchial remnants
- Fibromuscular stenosis
- Membranous diaphragm

Locations:

- Tracheobronchial remnants usually involves the lower one-third of the esophagus
- Fibromuscular stenosis and membranous diaphragm usually involve the middle one-third.
- Esophageal stenosis may affect any portion of the esophagus

Imaging findings:

- A segmental stricture with circumferential wall thickening and smooth tapering.
- The imaging appearances of esophageal stricture are similar whether it results from trauma, reflux esophagitis, or ingestion of a toxic substance.
- Knowledge of the patient's clinical history may help distinguish between the various types of esophageal stenosis by excluding other conditions that are associated with esophageal stricture.

Differential Diagnosis:
DYSPHAGIA

- Functional obstruction
- Motility disorders
  - Scleroderma
  - Achalasia
  - Chagas disease
  - Diffuse esophageal spasm
  - Diabetes
- Esophagitis
  - Reflux
  - Infections
  - Corrosive
  - Alcoholism

- Mechanical Obstruction
- Luminal
  - Foreign body
- Wall
  - Benign tumors
  - Malignant tumors
  - Strictures
  - Congenital webs and rings
  - Diverticuli
- Outside
  - Vascular anomalies
  - Lymphadenopathy

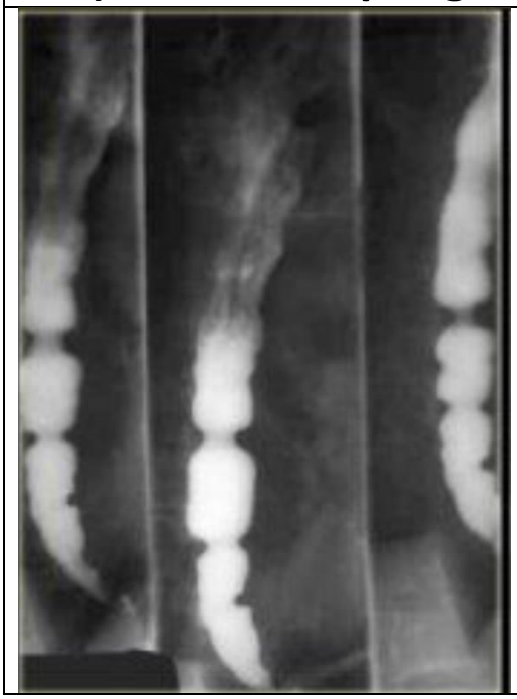
Esophageal Motility Disorders

❖Normal Esophageal Peristalsis:
✓ Primary contraction ✓ Secondary contraction
❖1ry Esophageal Motility Disorders
✓ Tertiary contractions, presbyesophagus (Aging process) ✓ Diffuse Esophageal Spasm ✓ Achalasia ✓ Hypercontracting Esophagus Hypertensive Esophagus (Nutcracker Esophagus)
❖2ry Esophageal Motility Disorders
✓ Collagen vascular disease (Scleroderma) ✓ Diabetes ✓ Chagas' Disease ✓ Amyloidosis ✓ Alcoholism ✓ MS ✓ Invasive Cancer

1) Tertiary Contractions (Presbyesophagus):

- Nonpropulsive
- Nonprogressive
- Cork-screw contractions
- Yo-Yo appearance

2) Diffuse Esophageal Spasm



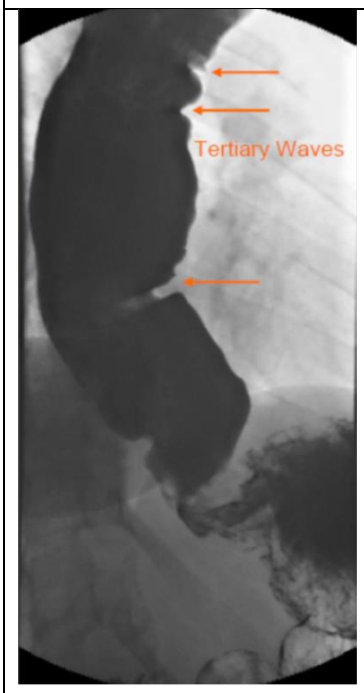
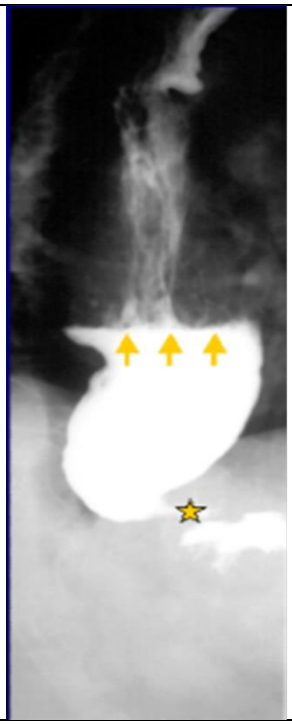
- Diffuse esophageal spasm produces intermittent contractions
- Mid and distal esophageal smooth muscle
- Associated with chest symptoms

3) Achalasia

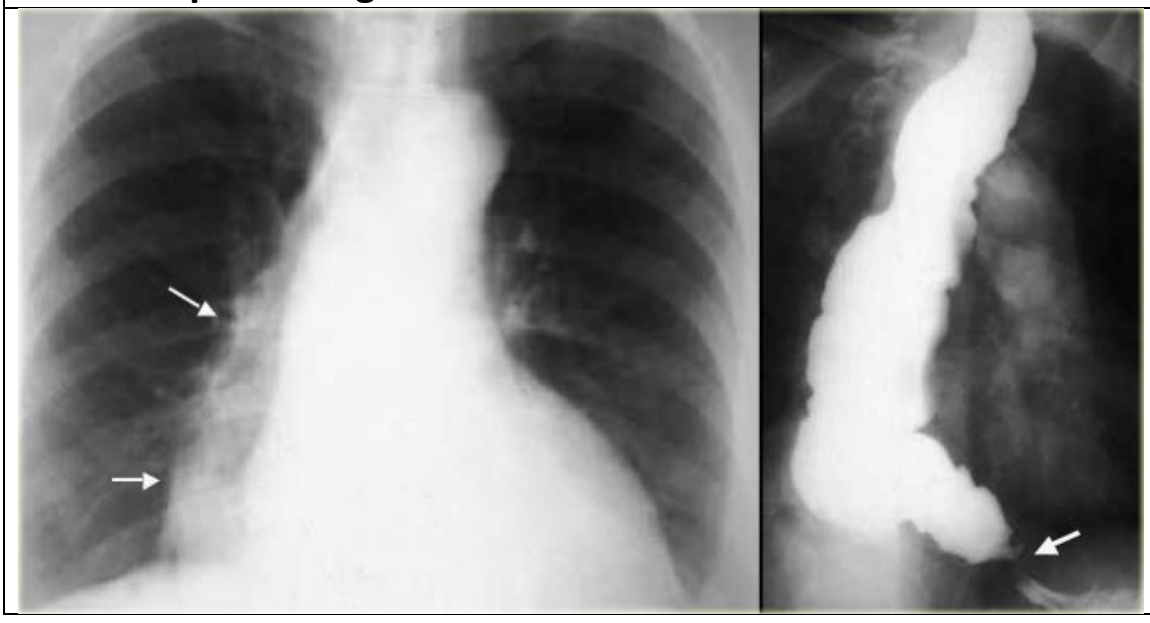
- Failure of lower esophageal sphincter to relaxation and loss of peristalsis in the distal esophagus.
- Emptying of esophagus occurs once pressure of the intralumenal material exceeds the pressure of the lower esophageal sphincter.
- Age: Middle age
- Clinical Picture: Progressive dysphagia to fluid > food

- **<u>Primary Achalasia:</u>**
  - Etiology unknown
  - Hereditary, degenerative, autoimmune and infectious
- **<u>Secondary Achalasia:</u>**
  - Due to underlying pathology (e.g., Chagas)
- **<u>Pseudo-Achalasia:</u>**
  - Usually malignancy (carcinoma of gastric cardia in >50% of cases)

Smooth tapered narrowing LES = bird-beak	**Dilated + tortuous esophagus = Sigmoid esophagus**	**Absent 1ry peristalsis**

3ry Peristalsis	Air-fluid level	Absent gastric air bubbles
		

Dilated esophagus (arrows) appears as long, well-defined structure paralleling heart



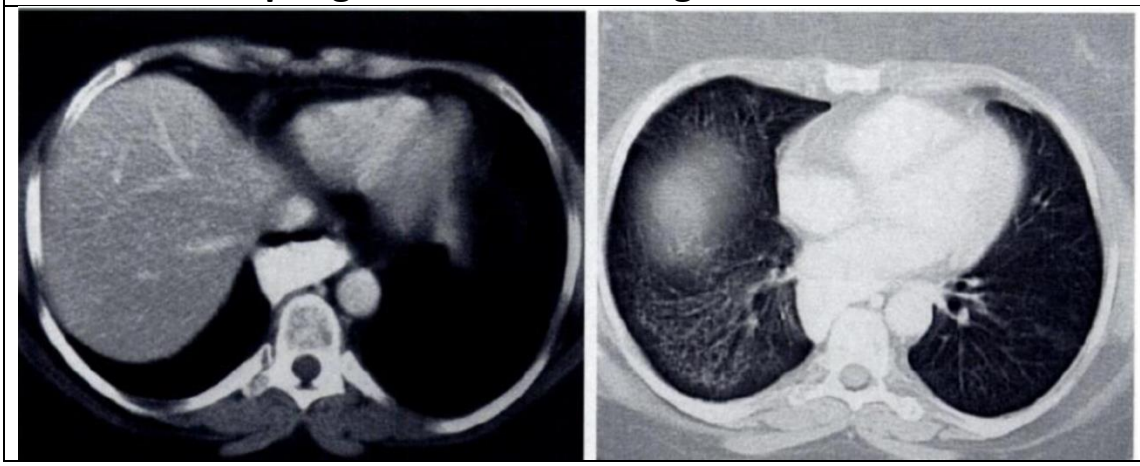
4) Nutcracker Esophagus

- A non-cardiac cause of chest pain attributed to high amplitude distal esophageal peristalsis.
- This is a controversial diagnosis that is made by manometry and does not have imaging manifestations

5) Scleroderma

- Fibrosis of smooth muscle
- Dilated esophagus with widely patent GEJ
- Resultant reflux
- Reflux esophagitis => ulceration => stricture (mild) => Barrett's => neoplasm

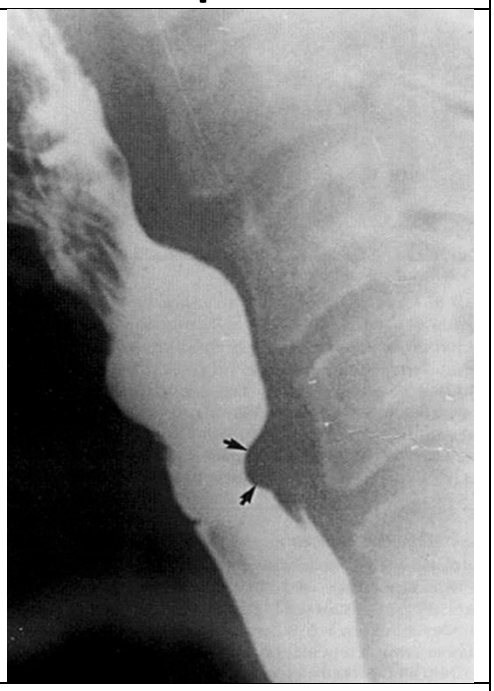
➢ **Dilated esophagus +Interstitial lung disease**



Upper Esophageal Sphincter

❖Normal Cricopharyngeal Muscle Impression:

- Smooth extrinsic impression on posterior wall of pharyngoesophageal junction by contracted muscle
- Normally relaxes with swallowing to allow passage of food
- Incomplete relaxation can be seen as protective mechanism in GER patients
- Smooth impression at C5-6 level

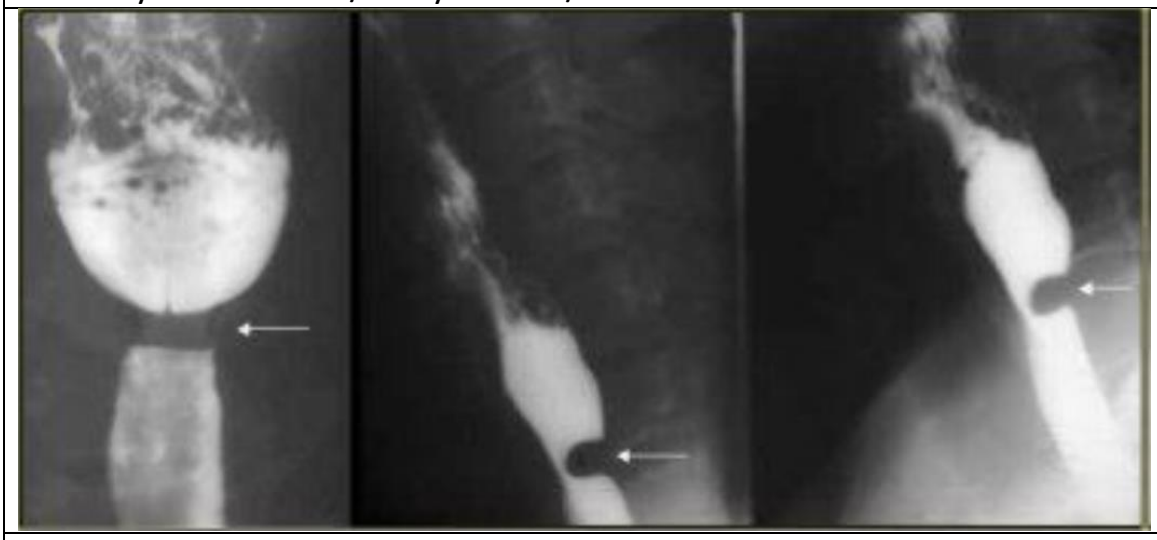


❖Normal Cricoid Impression:

- Smooth external indentation on the anterior wall of the esophagus at C5.

❖Cricopharyngeal Achalasia

- Primarily formed by cricopharyngeal muscle.
- Located at the C5-C6 level
- Delayed relaxation/ Early closure/ No relaxation



❖Cervical Osteophytes Indentation:

- Large anterior cervical osteophytes can impinge on pharyngoesophageal junction simulating cricoharyngeal achalasia

Esophageal Webs

- Thin ring-like mucosal constriction projecting into lumen most frequently from anterior wall of proximal cervical esophagus.

Plummer-Vinson syndrome:

- Middle aged females
- Esophageal web
- Dysphagia
- Iron deficiency anemia
- Stomatitis
- Glossitis

Esophageal Diverticula

- **Zenker's**
- **Killian-Jamieson**
- **Epiphrenic**
- **Midesophagus**
- **Aortopulmonary recess**

2 Typess of diverticulae:

a) Traction (True) Diverticulum:

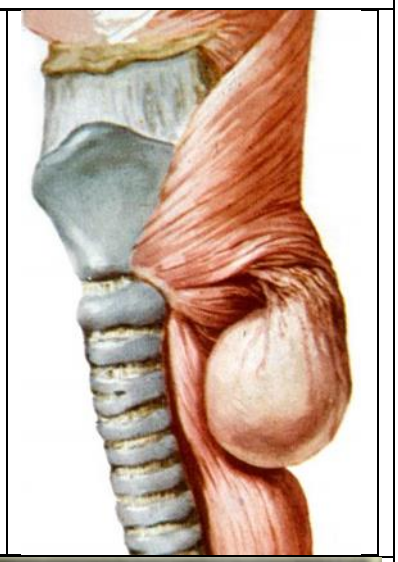
- Contain all layers of the esophagus,
- Tends to empty when esophagus is collapsed

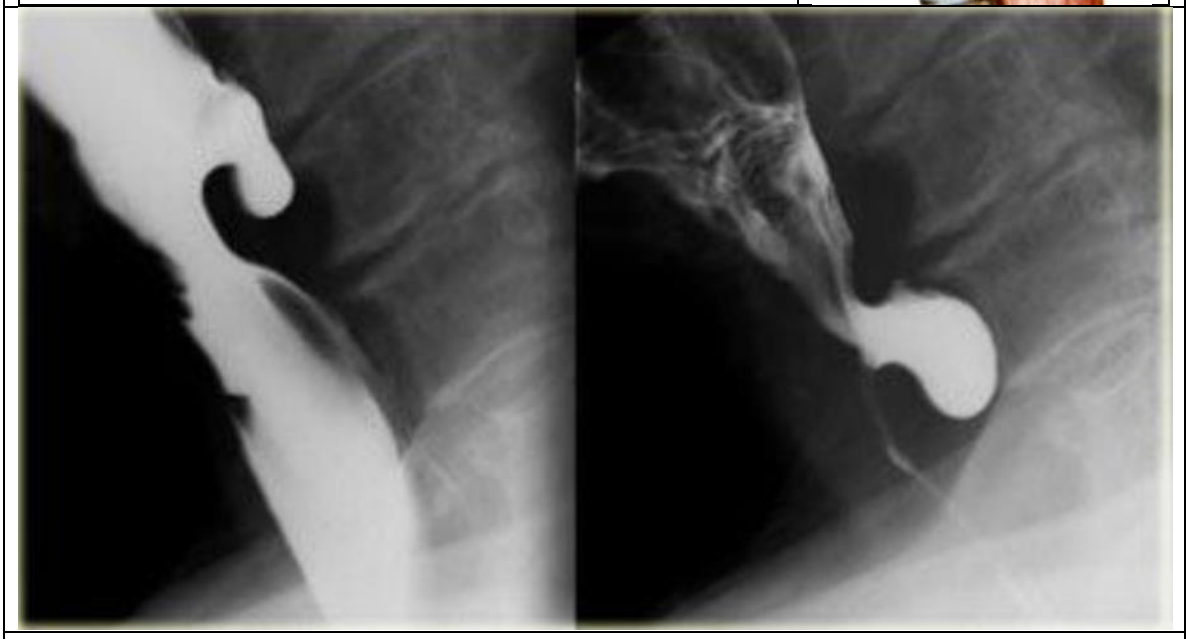
b) Pulsion (false) Diverticulum:

- Contain mucose & submucosa + No muscle layer
- Tend to remain filled after most of barium is emptied (lack of muscle)

1) Zenker's Diverticulum

- Pulsion (False) diverticulum
- Posterior midline
- Above cricopharyngeus muscle.
- Horizontal & oblique fibers of inferior constrictor muscles => Killian's dehiscence
- Associated incomplete cricopharyngeus muscle relaxation
- Neck at superior aspect of sac





Complications:

- Aspiration pneumonia (in 30% of cases)
- Bronchitis, bronchiectasis, lung abscess
- Diverticulitis, ulceration, fistula formation
- Risk of perforation during endoscopy or placement of nasogastric tube
- Risk of carcinoma (seen in 0.3% of cases)

2) Killian-Jamieson diverticulum (K-J)

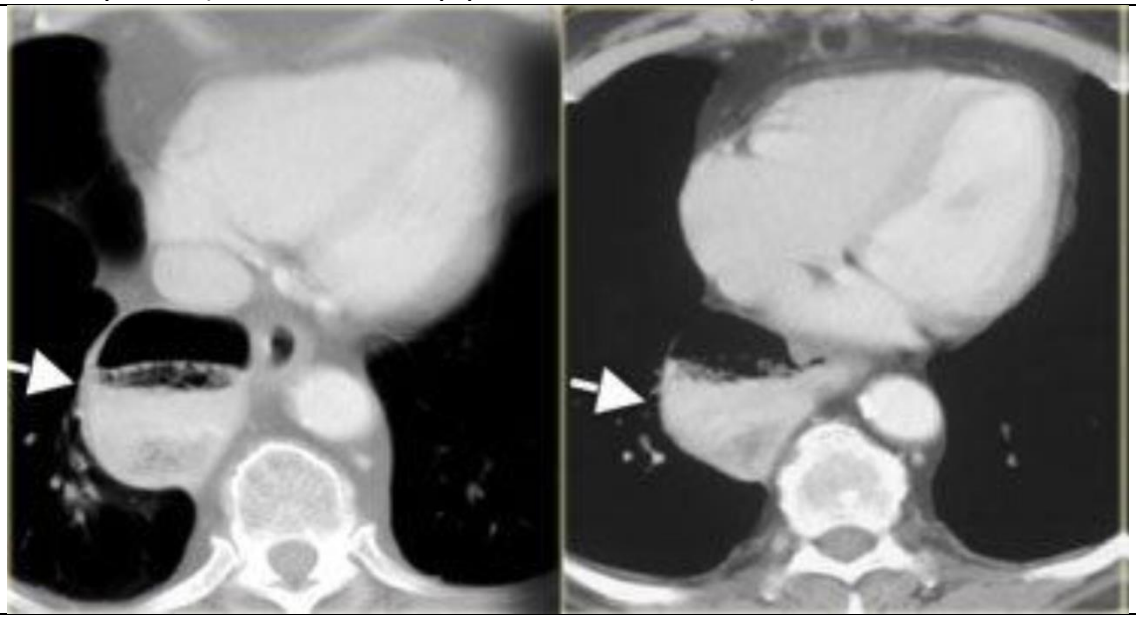
- Also known as lateral cervical esophageal pouches or diverticula
- Anterolateral wall of cervical esophagus (triangular area of weakness)
- Just below cricopharyngeus muscle
- Less common & smaller than Zenker diverticulum.
- Less likely to cause symptoms
- Less likely to be associated with overflow aspiration or gastroesophageal reflux than is Zenker diverticulum

3) Epiphrenic Diverticulum

- Pulsion diverticulum.

Complications:

- If large they can narrow the esophagus or lead to aspiration.
- Erosion with bleeding; inflammation with abscess
- Perforation; fistula formation; retained foreign body
- Neoplasm (carcinoma of epiphrenic diverticula)

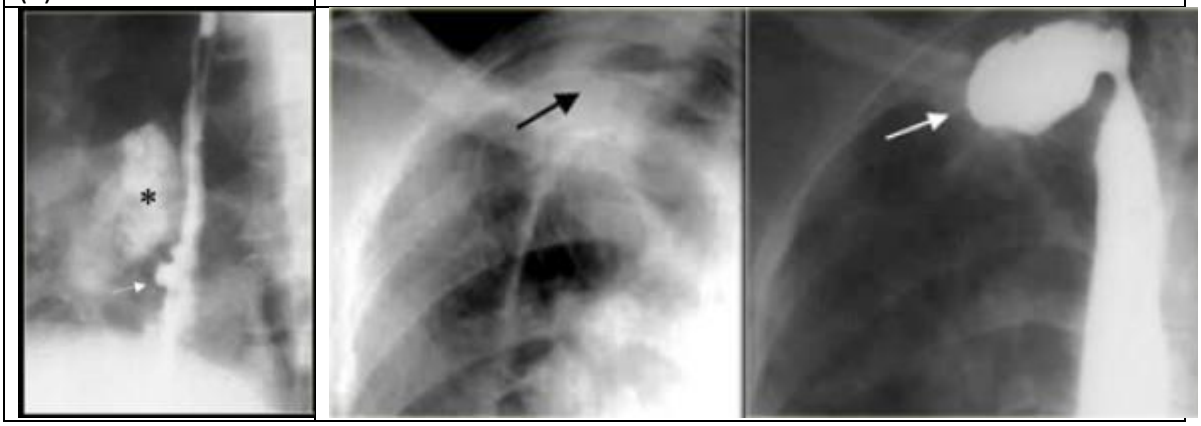


4) Aorto-pulmonary Window Diverticulum

- The normal esophagus transiently protrudes into the aortopulmonary window.
- Fixed protrusion is an inconsequential diverticulum.

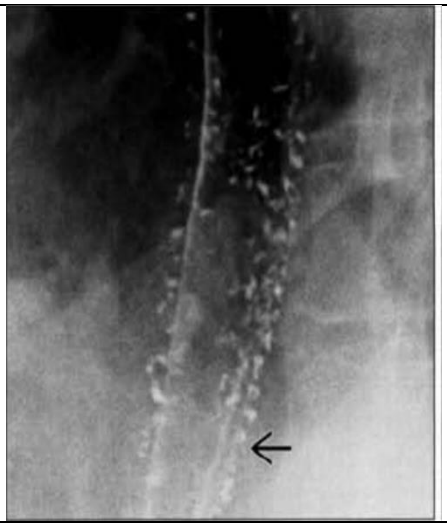
5) Traction Diverticulum

Traction diverticulum (arrow) due to hilar granulomatous Calcified adenopathy (*).	Traction diverticulum (arrows) secondary to post primary TB.



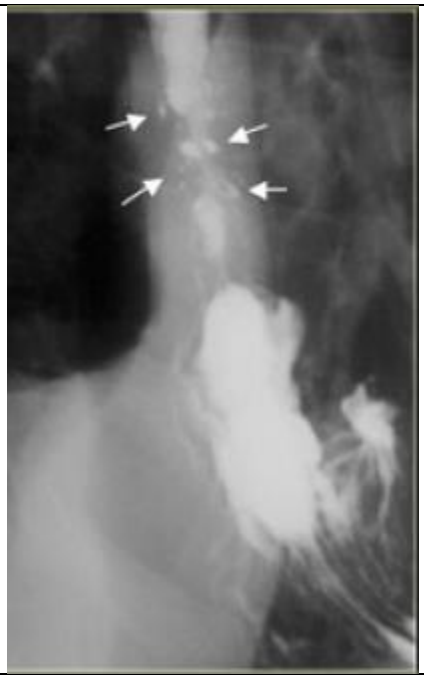
6) Intramural Pseudodiverticulosis

- Caused by dilation of excretory ducts of deep mucous glands
- Outpouchings: Barium-filled; innumerable; tiny;
- In longitudinal view: rows parallel to long axis of esophagus
- Intramural tracks: Bridging between adjacent pseudodiverticula.
- Associated with candidia esophagitis.



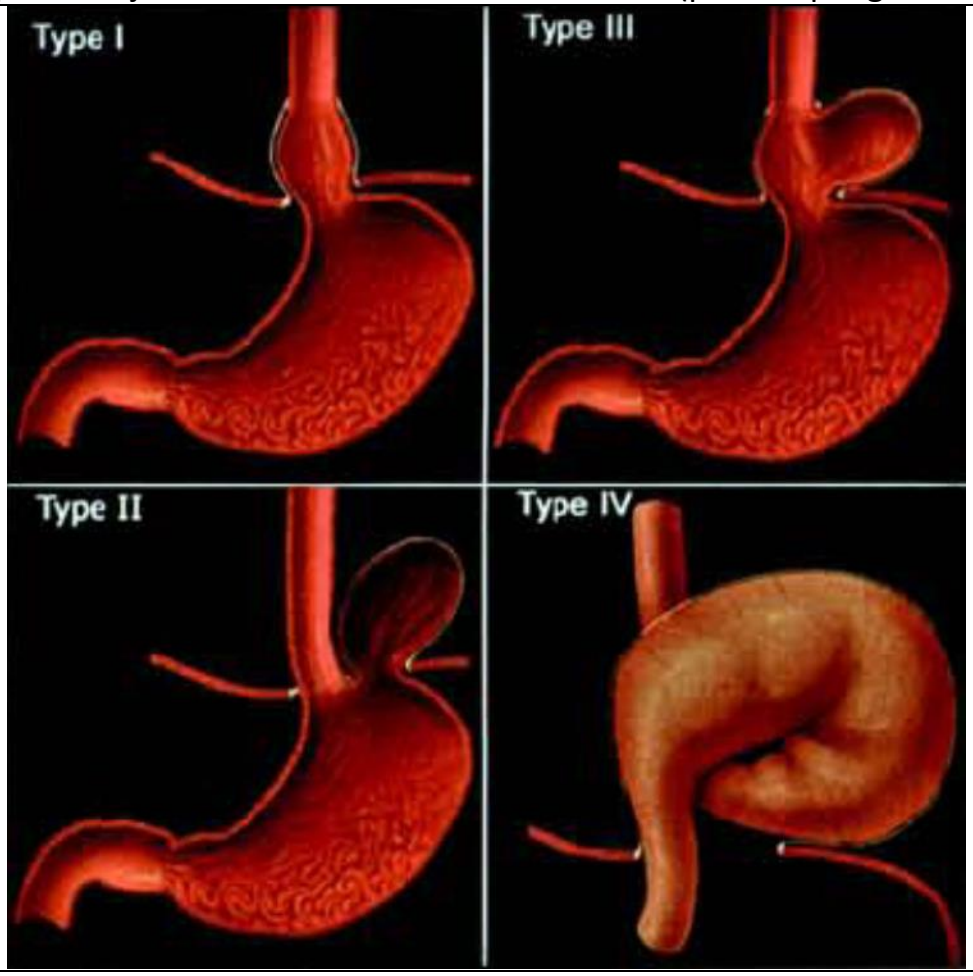
7) Pseudodiverticula

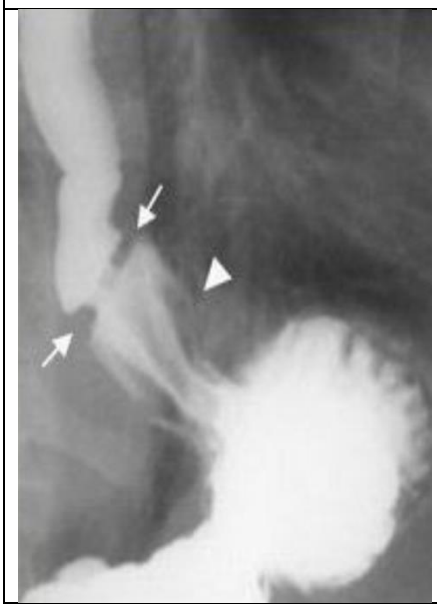
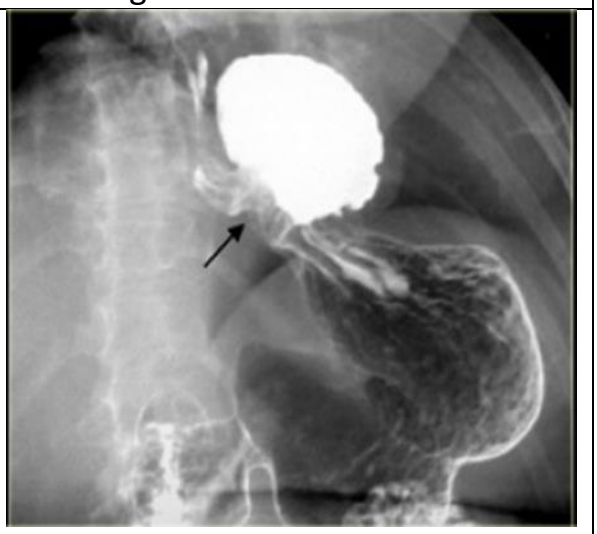
- Can be seen in reflux esophagitis.
- Patient with a hiatus hernia, reflux esophagitis, and pseudodiverticula (arrows) at site of proximal stricture



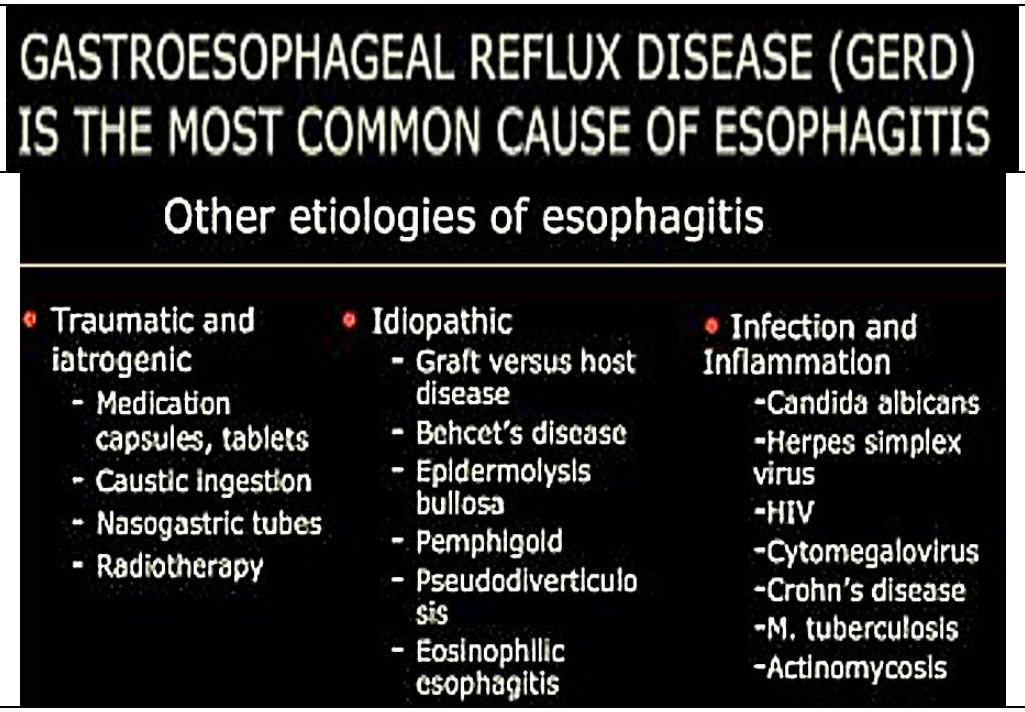
Hiatus Hernia

- Type I: GE junction and gastric cardia are intrathoracic (sliding hiatal hernia)
- Type II: GE junction still intraabdominal + gastric fundus intrathoracic (paraesophageal hernia)
- Type III: Both GE junction + gastric fundus are in chest (paraesophageal hernia)
- Type IV:GE junction and all of stomach in chest (paraesophageal hernia)



Sliding Hiatal Hernia	Paraesophageal hernia
Lower esophageal mucosal ("B")ring observed 2 cm or more above diaphragmatic hiatus	• Portion of stomach anterior or lateral to esophagus in chest • Frequently nonreducible • ± Gastric ulcer of lesser curvature at level of diaphragmatic hiatus • ± Entire stomach herniated into chest and • inverted or upside-down configuration
	

Esophagitis



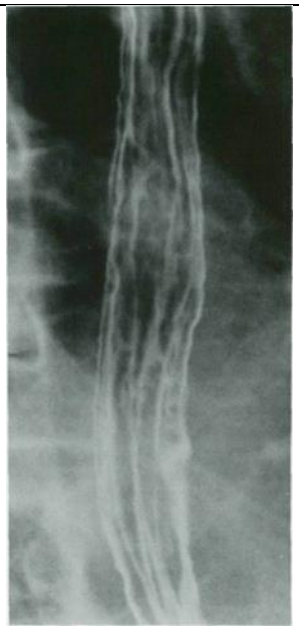
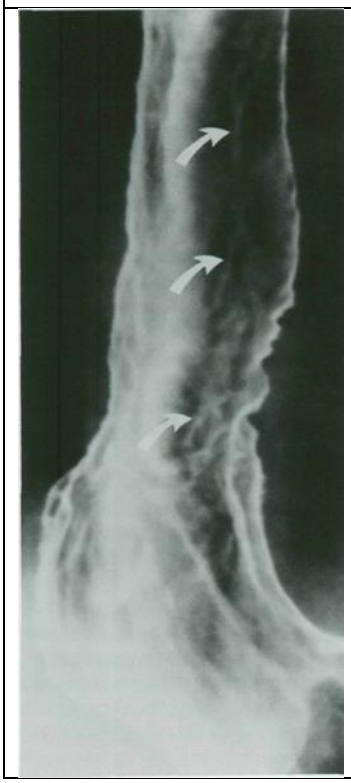
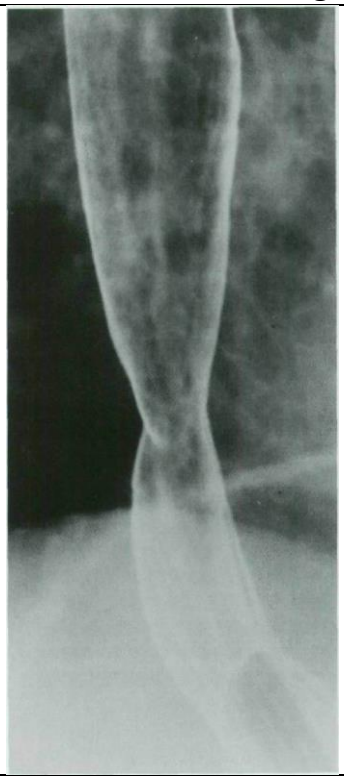
1) GERD / Reflux Esophagitis

- Is the most common inflammatory disease of esophagus
- Inflammation of esophageal mucosa due to gastroesophageal reflux

- Location: Distal Third of Esophagus

Imaging findings on Barium swallow:

- Reticular pattern = fine nodular or granular appearance.
- Mucosal folds: Thickened – irregular
- **Peptic Ulcer**: shallow ulcers or erosions surrounded by lucent halo.
- **Peptic stricture:**
  - Symmetric scarring: Smooth tapering concentric narrowing
  - Asymmetric scarring: Asymmetric narrowing + Focal sacculations.
  - Fixed transverse folds (Stepladder appearance)
- **Inflammatory polyp:**
  - A single thickened mucosal fold arising at the gastric cardia and extending through gastro-esophageal junction.

Fine nodular or granular mucosa	Thickened, irregular mucosal folds	Superficial Tiny Ulcers (arrows)
		
Long flowing ulcers (arrows)	Peptic stricture with smooth, tapered concentric narrowing	Peptic stricture with multiple sacculations
		

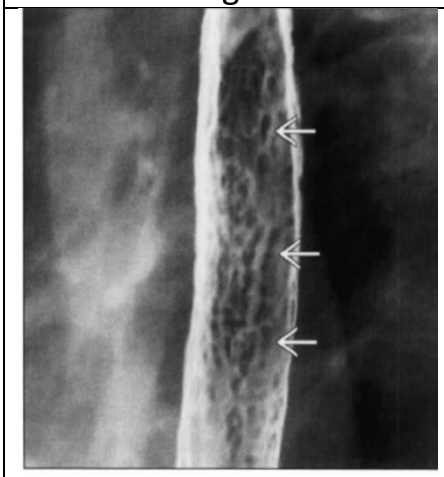
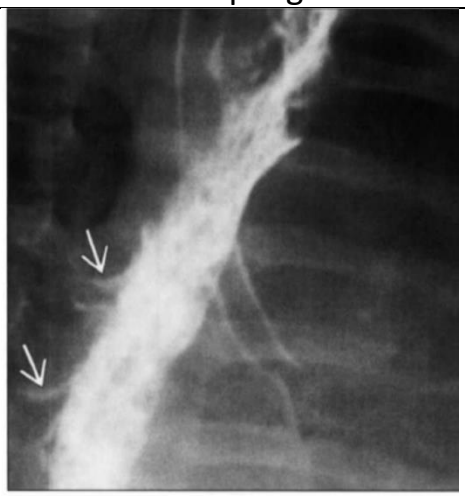
Inflammatory esophgo-gastric polyp	Stepladder pattern	Eccentric scarring & sacculations

❖ Barrett's Esophagus:

- Metaplasia of normal squamous epithelium to a gastric columnar epithelium
- is the result of long-standing reflux esophagitis.
- Most patients have reflux and a hiatus hernia.
- Premalignant condition associated with increased risk of esophageal adenocarcinoma
- Mid or high esophageal ulcer
- Mid or high esophageal web-like stricture
- Reticular mucosal pattern

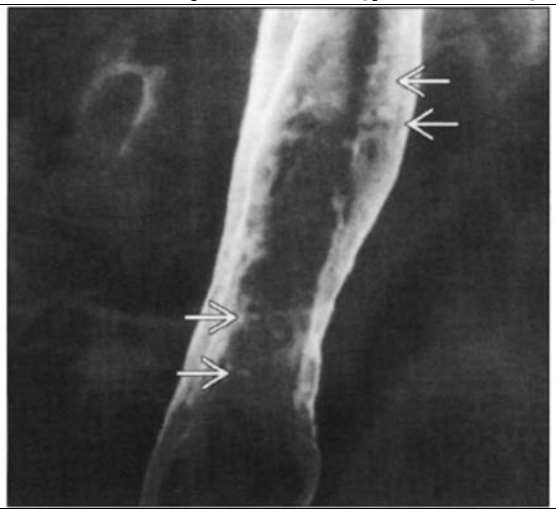
2) Esophageal Candidiasis

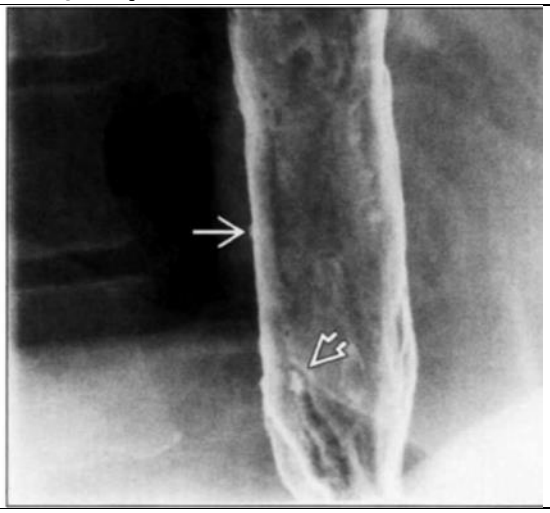
- Infectious esophagitis caused by fungi of Candida species, usually Candida albicans
- Mucosal plaques in immune-compromised patients
- Predominantly mid or upper esophagus
- Often spares distal esophagus

Plaques: Numerous longitudinally oriented filling defects	Discrete aphthoid ulcers that can mimic viral esophagitis
	
"Shaggy" esophagus	Pseudo-diverticulosis

3) Herpetic Esophagitis

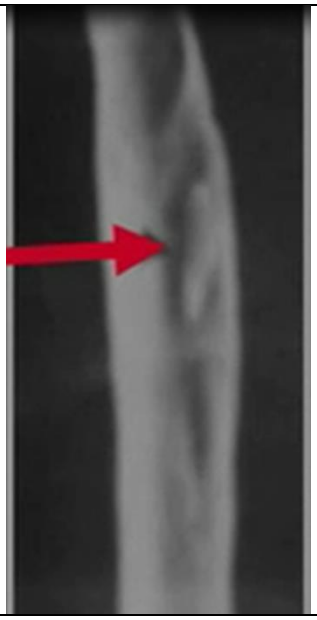
- **Multiple small (punctate) (<1cm) superficial ulcers**





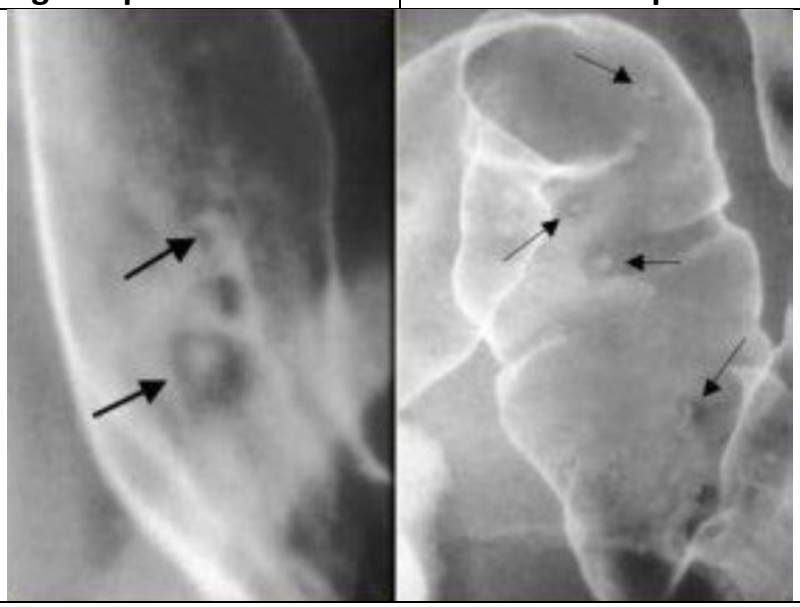
4) CMV / HIV Esophagitis

- **One or more giant (> 1 cm) flat ulcers in mid-distal esophagus**



5) Crohn's Esophagitis

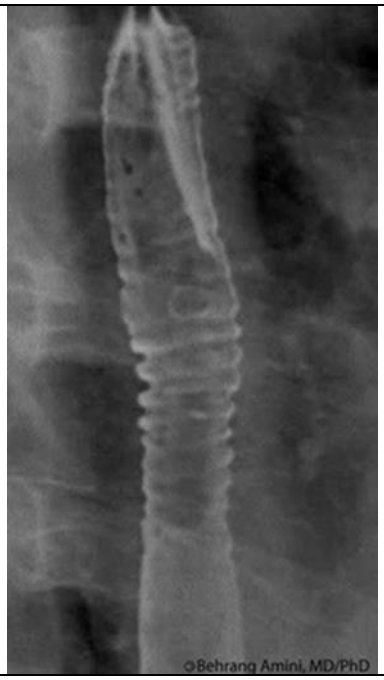
➢ Esophageal aphthous ulcers	➢ Colonic aphthous ulcers



6) Idiopathic Eosinophilic Esophagitis = Feline Esophagus

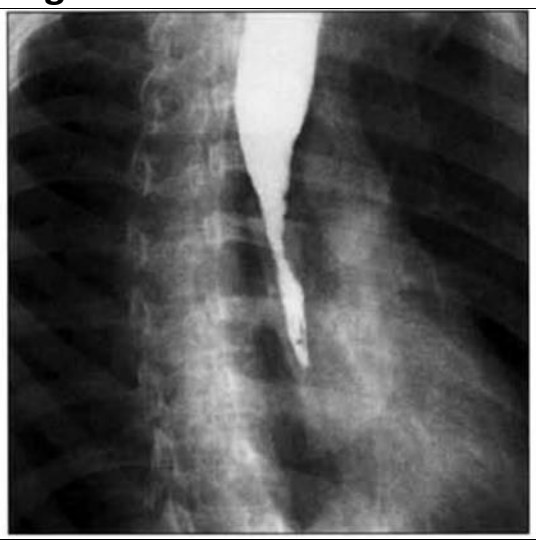
Idiopathic eosinophilic esophagitis is thought to develop as an inflammatory response to ingested food allergens.
M>>F

<u>Ringed esophagus</u> =
Multiple, fixed, closely spaced, concentric rings that traverse an area of esophageal stricture.



7) Corrosive Esophagitis

- **Mid-distal esophageal long segment stricture.**

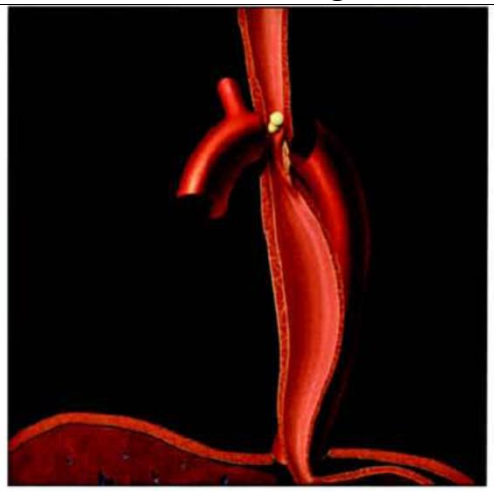


8) Drug Induced Esophagitis

- Definite temporal relationship between ingestion of offending drug & onset of esophagitis

Location

- Most common site: mid-esophagus
  - Near level of aortic arch or left main bronchus
- Larger areas of ulceration; with potassium chloride & quinidine; in patients with cardiomeg



Graphic shows medication pills "stuck" at level of aortic arch with focal stricture and ulceration.

Esophagram shows broad shallow ulceration (arrow) at aortic arch level. Patient had odynophagia and recent tetracycline ingestion. Spontaneously resolved.

9) Radiation Esophagitis

Acute RE:

- Superficial ulcers
- Thickened mucosal folds due to edema
- May be seen within 7-10 days of RT
- Location: Usually conforms to radiation portal.

Chronic RE

- Strictures: Concentric, smooth, tapered narrowing
- Ulcers at site of extrinsic compression by mediastinal lymphadenopathy, tumor
- Late developing deep ulcers; may progress to fistula formation
- Fistula: Left main bronchus; most frequent site
- Radiation necrosis; usually within first year of RT
- Avoid ionic; use nonionic water soluble contrast if suspected
- Retraction of esophagus; related to lung resection & regional fibrosis
- location: Upper or mid-esophagus; within radiation portal
- Usually 4-8 months after completion of RT

Esophageal Stricture

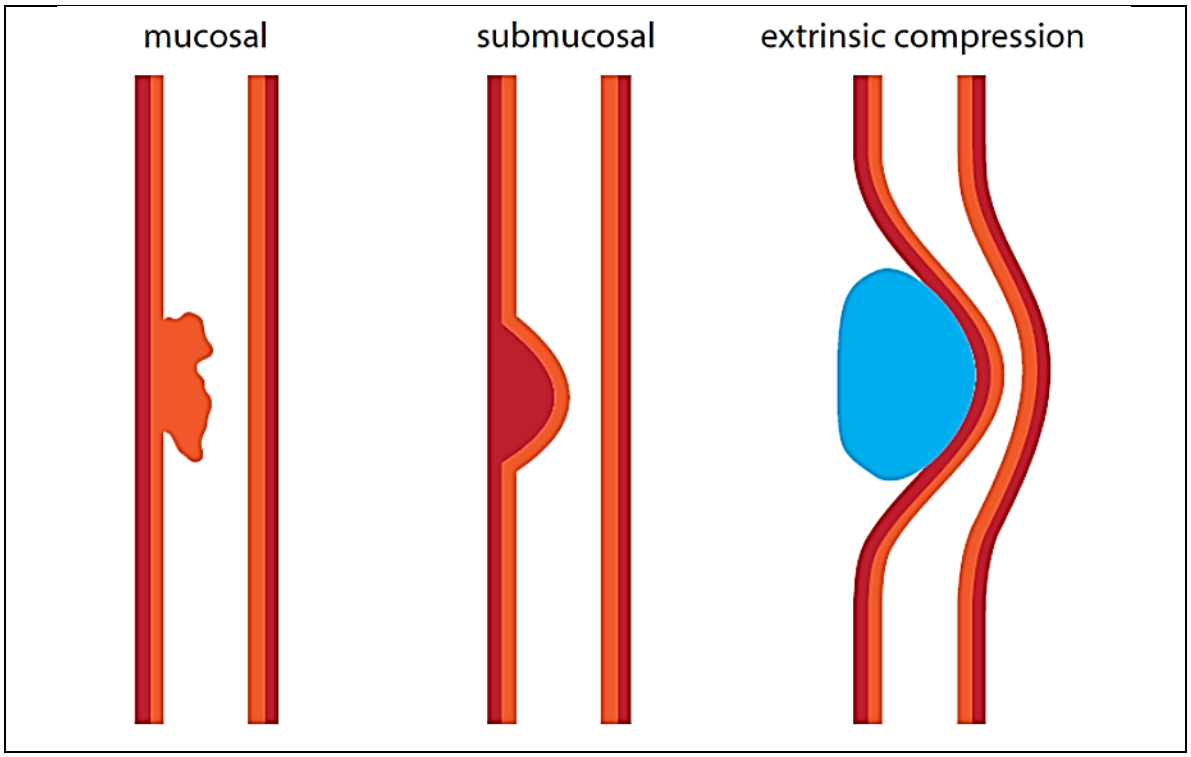
❖ Upper/Mid Esophageal Stricture

Barrett esophagus	Focal or tapered	Hiatal hernia, gastroesophageal reflux, reticular pattern	History of reflux
Mediastinal irradiation	Long, tapered	Surgical clips (in some cases)	Radiation dose ≥5,000 cGy
Ingestion of caustic substance	Extremely long	Gastric abnormalities	Ingestion of strong acid or base
Drug ingestion	Variable	Enlarged left side of heart	Ingestion of quinidine, nonsteroidal anti-inflammatory drugs, alendronate, potassium chloride
Congenital esophageal stenosis	Variable	Ringlike indentations	Chronic dysphagia, food impactions
Skin diseases	Tapered	Webs	Lesions on skin and mucous membranes
Esophageal intramural pseudodiverticulosis	Variable	Pseudodiverticula	No other cause for stricture

❖ Distal Esophageal Stricture

Gastroesophageal reflux	Tapered	Hiatal hernia in 95% of cases, sacculations, fixed transverse folds, pseudodiverticula	History of reflux
Scleroderma	Long, marked	Sacculations	Scleroderma
Nasogastric intubation	Long, rapidly progressive	Hiatal hernia	Prior intubation
Zollinger-Ellison syndrome	Long	Hiatal hernia	High serum gastrin levels
Alkaline reflux esophagitis	Long, rapidly progressive	Hiatal hernia	Prior partial or total gastrectomy

Esophageal Neoplasms



Epithelial neoplasms	Nonepithelial neoplasms
SCC	Leiomyoma
SCC variants	GIST
Spindle cell carcinoma	Sarcomas, particularly leiomyosarcoma
Basaloid squamous carcinoma	Lymphoma
Verrucous carcinoma	Metastasis
Squamous papilloma	Malignant melanoma
Adenocarcinoma	Granular cell tumor
Adenosquamous carcinoma	Hemangioma
Adenoma	Schwannoma
Neuroendocrine neoplasms	Neurofibroma
Salivary gland–type tumors	Glomus tumor
Adenoid cystic carcinoma	
Mucoepidermoid tumor	
Pleomorphic adenoma	

Benign neoplasms and Cysts

- Papilloma
- Adenoma
- Leiomyoma
- Other mesenchymal tumors
- Granular cell myoblastoma
- Fibrovascular polyp
- Duplication cyst
- Retention cyst

1) Leiomyoma

- most common benign esophageal neoplasm.
- 50 times less common than esophageal carcinoma

Most common mesenchymal tumor:

- ***Esophagus => Leiomyoma***
- ***Remainder of GIT => GIST predominate.***

Ba swallow:

En face view:

- Round or ovoid filling defects sharply outlined by barium on each side
- Smooth surface

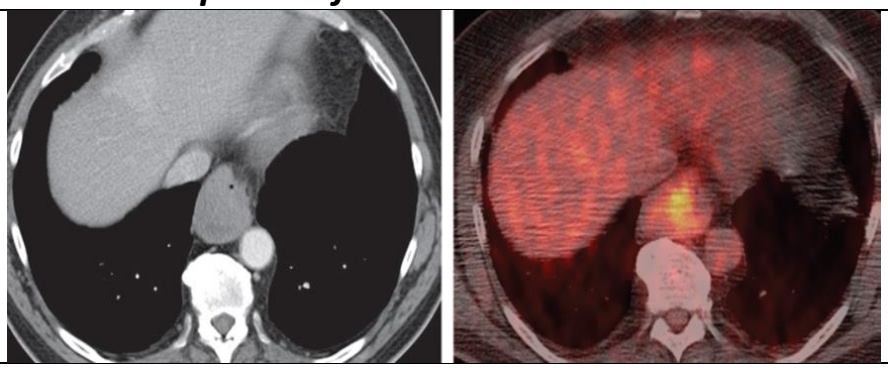
Profile view:

- Lesion forming slightly obtuse angles with adjacent esophageal wall

CT:

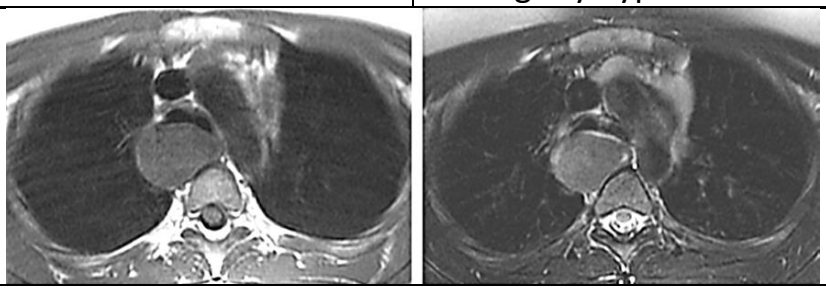
- Calcified esophageal mass is almost always a leiomyoma
- Smoothly marginated
- Homogeneous masses
- ± Calcification.
- NCCT: isoattenuating or hypoattenuating to muscle
- +C: They demonstrate homogeneous enhancement without necrosis

- ***PETCT: avid uptake of FDG.***



MRI

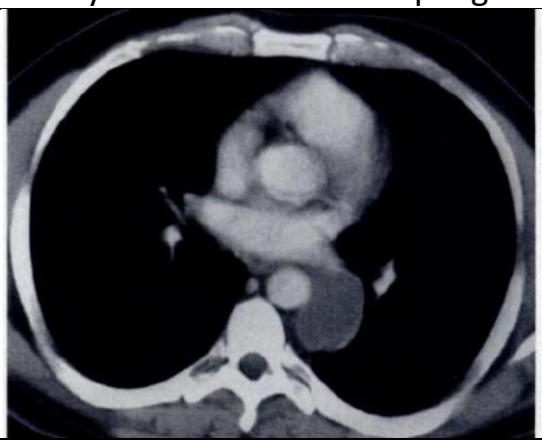
T1: isointense to muscles.	T2: slightly hyperintense



2) Foregut Duplication Cyst

- 2nd most common benign esophageal lesions after leiomyomas.
- 0.5%-2.5% of all tumors or tumorlike lesions of the esophagus
- 10%- 15% of all alimentary tract duplications.
- In many cases (approximately 60%), the cyst is in the lower esophagus.

CT scans of esophageal cysts show a homogeneous mass of low attenuation with smooth borders



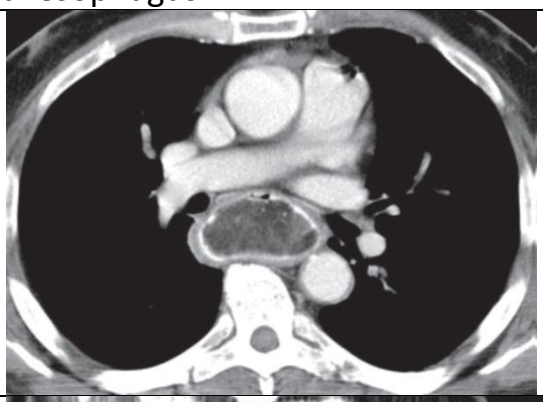
3) Fibrovascular Polyp

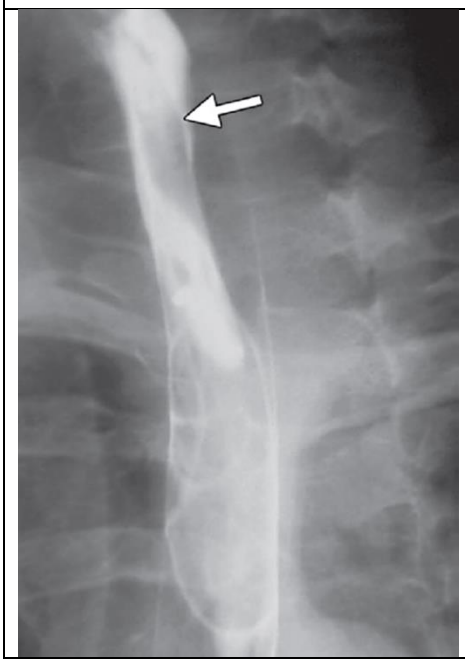
- Intraluminal esophageal polyps
- Consist of varying proportions of
- Fibrous + adipose tissue + blood vessels.
- 1%–2% of benign esophageal tumors

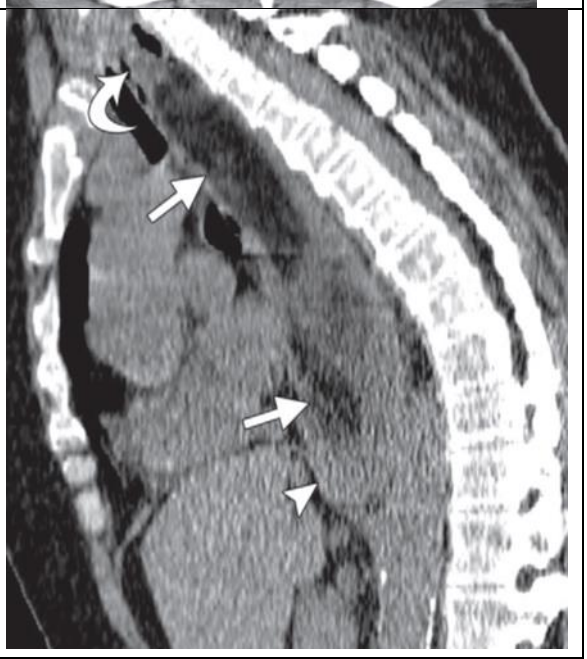
- Giant, smooth, sausage-shaped, intraluminal, expansile mass
- Size: Variable in size (average length of 15 cm)
- Pedunculated, intraluminal, gigantic mass
- Attached to cervical esophagus by a pedicle
- Extend inferiorly into middle or distal esophagus

Imaging findings:

- A heterogeneous appearance:
- Areas of fat attenuation/signal
- Areas of soft-tissue attenuation/signal



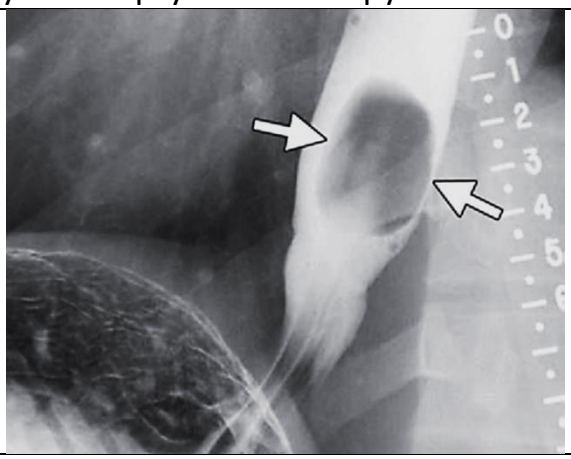




4) Granular Cell Tumors

- are most commonly found in the skin, subcutaneous tissue, and tongue.
- 5%–8% arise in GIT, and one-third of these tumors arise in the esophagus.
- small tumors discovered incidentally at autopsy or endoscopy

- Small submucosal mass in the distal esophagus



5) Squamous Papilloma

- Benign hyperplastic epithelial lesion consisting of a fibrovascular core with multiple small projections.
- Small sessile polyp with a smooth or slightly lobulated contour

Esophageal Cancer

- 5th most common cause of cancer-related deaths in men
- 8th most common cause of cancer-related deaths in women
- 5-year relative survival rate < 20%
- Age = 5th–8th decades

Risk Factors:

- Age > 40
- Black > White = 4:1
- Male > female = 7:1
- Alcohol
- Achalasia
- Barrett's esophagus
- Scleroderma,
- Smoking

Clinical Features:

- Dysphagia, odynophagia, nausea, vomiting
- Anorexia, weight loss, debility
- Chronic reflux esophagitis or Barrett's esophagus

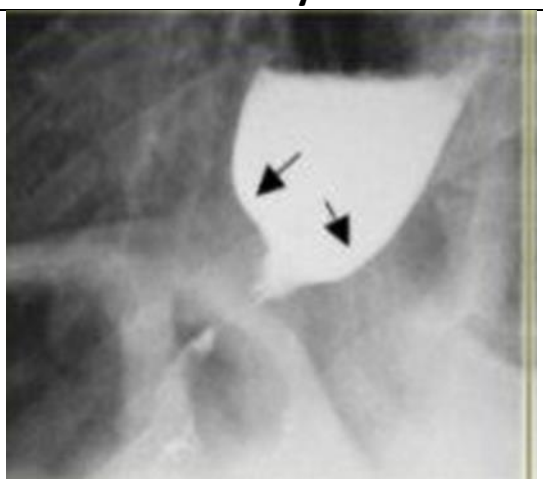
Histology:

- 90% of esophageal cancers are either SCCs or adenocarcinomas
- SCCs are evenly distributed between the middle and lower esophagus.
- Most of all adenocarcinomas are found in the distal esophagus

Barrett's esophagus and Adenocarcinoma:

- Barrett's esophagus is a proven risk factor for the development of an adenocarcinoma.
- The incidence of cancer in Barrett's however is controversial.

❖ **Ba Swallow Patterns:**

Polypoidal	**Infiltrative Ulcerative**
Varicoid	**Superficial Spreading**
Stricture: Irregular, asymmetric stricture	**Pseudo-Achalasia: Eccentric, shoulders are asymmetric.**
	

AJCC-UICC staging system

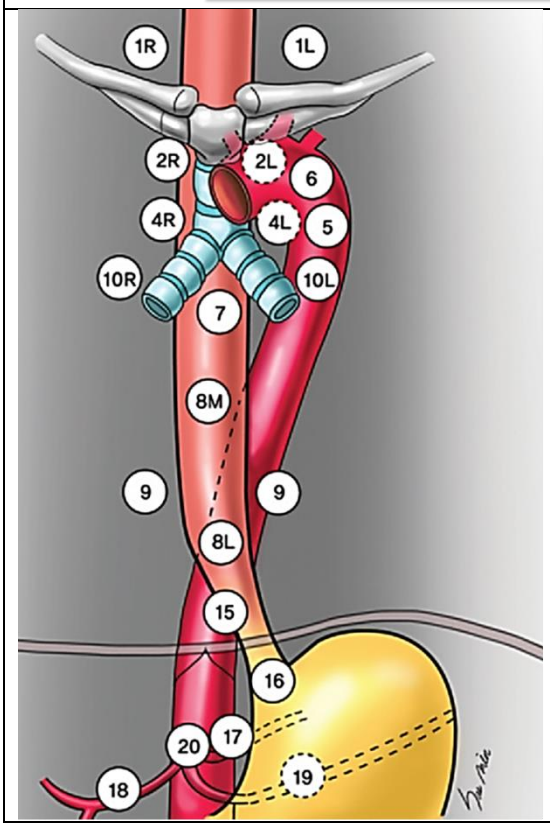
Seventh Edition
Tis: high-grade dysplasia
T1: invasion of lamina propria, muscularis mucosae, or submucosa
T2: invasion of muscularis propria
T3: invasion of adventitia
T4: invasion of adjacent structures
T4a: resectable (pleura, pericardium, or diaphragm)
T4b: unresectable (aorta, vertebral body, or trachea)
N0: absent
N1: 1–2 regional LNs
N2: 3–6 regional LNs
N3: ≥7 regional LNs
M0: absent
M1: present

Table 5: Treatment of Esophageal Cancer According to Seventh Edition of TNM Staging System

T	N	M	Treatment
T1a	N0	M0	Endoscopic tissue ablation (preferred) or surgical resection
T1b	N0	M0	Surgical resection
T1b T2 T3 T4a	Any N	M0	Surgical resection with or without preoperative chemoradiation therapy; definitive chemoradiation therapy for patients who decline surgery
T4b	Any N	M0	Definitive chemoradiation therapy
Any T	Any N	M1	Palliative therapy

❖Regional LNs in Esophageal Cancer:

Cervical esophagus
Scalene
Internal jugular
Upper and lower cervical
Periesophageal
Supraclavicular
Intrathoracic esophagus (upper, middle, and lower)
Upper periesophageal (above the azygos vein)
Subcarinal
Lower periesophageal (below the azygos vein)
Gastroesophageal junction
Lower esophageal (below the azygos vein)
Diaphragmatic
Pericardial
Left gastric
Celiac



Regional LNs:

- 1L = left supraclavicular
- 1R = right supraclavicular
- 2L = left upper paratracheal
- 2R = right upper paratracheal
- 4L = left lower paratracheal
- 4R = right lower paratracheal
- 5 = aortopulmonary
- 6 = anterior mediastinal
- 7 = subcarinal
- 8M = middle paraesophageal
- 8L = lower paraesophageal
- 9 = pulmonary ligament
- 10L = left tracheobronchial
- 10R = right tracheobronchial
- 15 = diaphragmatic
- 16 = paracardial
- 17 = left gastric
- 18 = common hepatic
- 19 = splenic
- 20 = celiac.

❖N disease

Size criteria of metastatic LN:

- Intrathoracic and abdominal LNs >1 cm in short axis
- Supraclavicular LNs > 5 mm in short-axis

❖M disease

- M1a indicating metastases to nonregional LNs
- M1b indicating metastases to distant sites

❖ Cancer Location: 4 Divisions of the Esophagus

a) Cervical esophagus

- 15–20 cm from the incisors
- begins at the level of the cricopharyngeus muscle
- ends at the level of the sternal notch

b) Upper thoracic esophagus

- 20–25 cm from the incisors
- Begins at the sternal notch
- Ends at the azygos arch.

c) Middle thoracic esophagus:

- 25–30 cm from the incisors
- Begins at level of the azygos arch
- Ends at the level of the inferior pulmonary vein.

d) Lower thoracic esophagus

- 30–40 cm from the incisors
- Begins at level of the inferior pulmonary vein
- Ends at the lower esophageal sphincter at esophagogastric junction
- includes intraabdominal portion

❖Esophago-Gastric Junction Tumors

Tumors in the esophagogastric junction are staged as esophageal cancer if

- The tumor's epicenter is within the lower thoracic esophagus or at the esophagogastric junction
- The epicenter is within the proximal 5cm of the stomach and the tumor extends into the esophagus

Tumors in the esophagogastric junction are staged as gastric cancer if:

- Tumors with an epicenter within 5 cm of the stomach without extension into esophagus
- Tumors with an epicenter in the stomach that is more than 5 cm from the esophagogastric junction

❖Imaging Modalities:

- **Endoscopic US**
- **CT**
- **PET**

❖Role of Endoscopic US

- Endoscopic US can accurately help differentiate between T1, T2, and T3 disease, which is important for neoadjuvant treatment.
- Combined use of endoscopic US and endoscopic US–guided fine needle aspiration in the evaluation of LNs metastasis has been shown to have a greater accuracy than does endoscopic US alone.

❖Role of CT

- Normal esophageal wall thickness < 3 mm.
- Abnormal esophageal wall thickness > 5 mm
- T1 & T2: Asymmetric wall thickening of the esophageal is a primary but nonspecific CT finding of esophageal cancer.
- T3: Abnormal wall thickening and periesophageal fat infiltration + preservation of the triangular fat space between the esophagus, aorta, and spine adjacent to the primary tumor + preservation of the fat plane between mass and heart.
- Exclusion of T4 disease, as indicated by the preservation of fat planes between the esophageal cancer and adjacent structures, is the most important role of CT in the determination of T status

CT Findings:

- Eccentric or circumferential esophageal wall thickening (>3mm if distended or >5mm if not distended)
- Irregular eccentric lumen.
- Esophageal distention proximal to obstructing tumor.

❖Stage T4

Mediastinal invasion:

- Loss of fat planes between the tumor and adjacent structures in the mediastinum
- Displacement or indentation of other mediastinal structures.

Tracheobronchial invasion:

- Posterior wall indentation/bowing
- Tracheobronchial displacement/compression ± collapse of lobes
- Tracheoesophageal fistula.

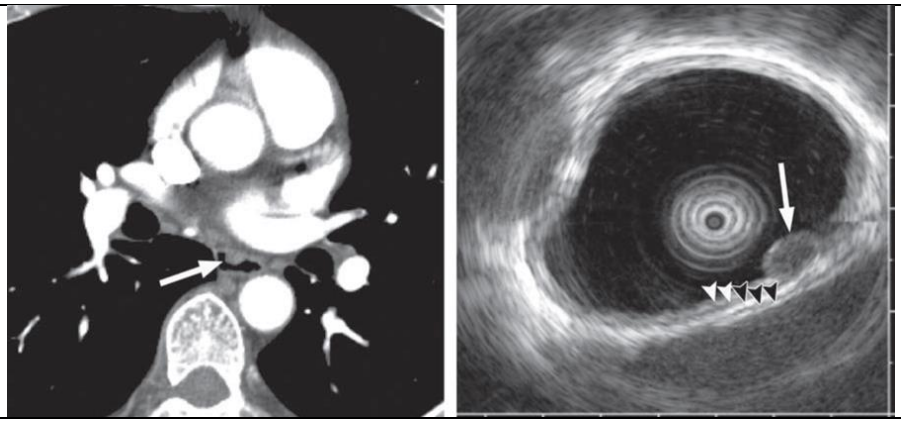
Aortic invasion:

- Contact of the tumor with > 90° of the aortic circumference
- Obliteration of the triangular fat space between the esophagus, aorta, and spine adjacent to the primary tumor

Pericardial invasion:

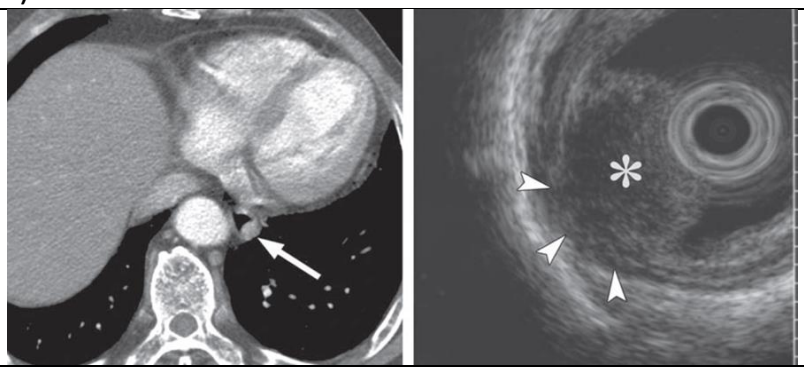
- Obliteration of fat plane between esophageal mass and pericardium
- Pericardial thickening, pericardial effusion
- Indentation of the heart with a concave deformity

T1 N0 M0 (stage I)



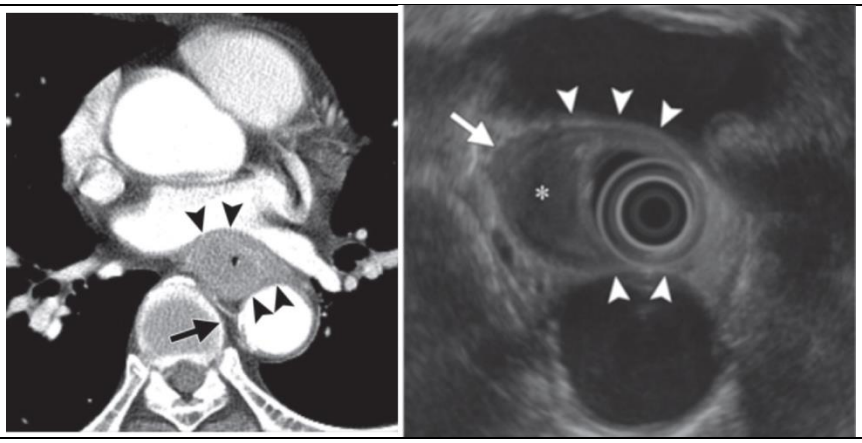
T2 N0 M0 (stage IIA)

Endoscopic US: mural nodule (*) with penetration into the fourth (hypoechoic) layer of the esophageal wall (muscularis propria) (arrowheads)



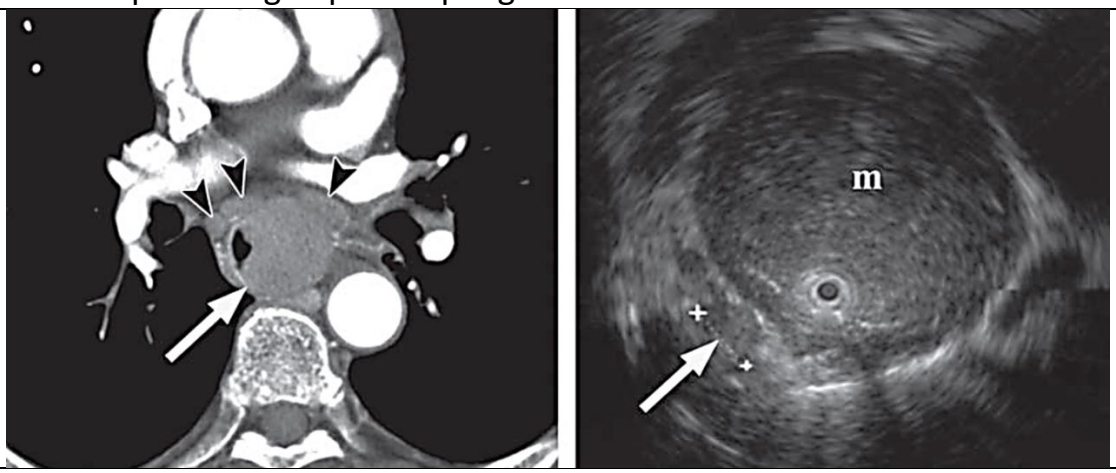
T3 N0 M0

CT: Diffuse wall thickening in the lower esophagus and periesophageal fat infiltration



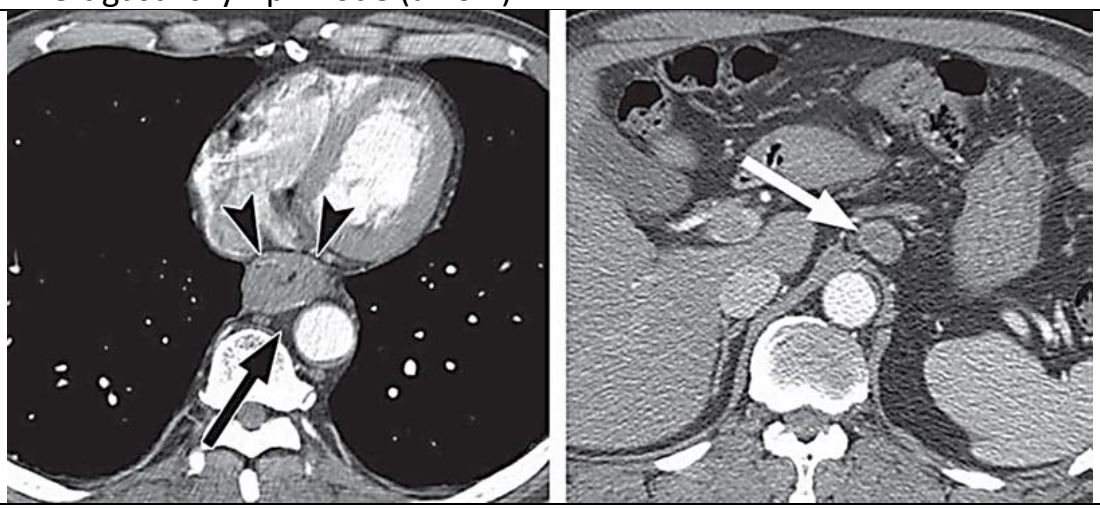
T3 N1 M0 (stage III)

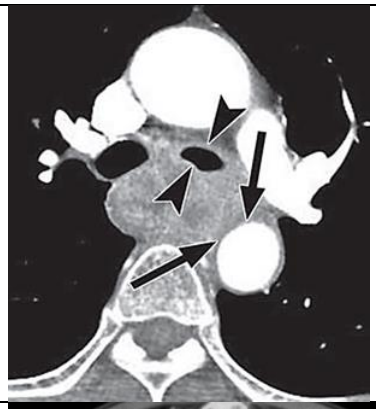
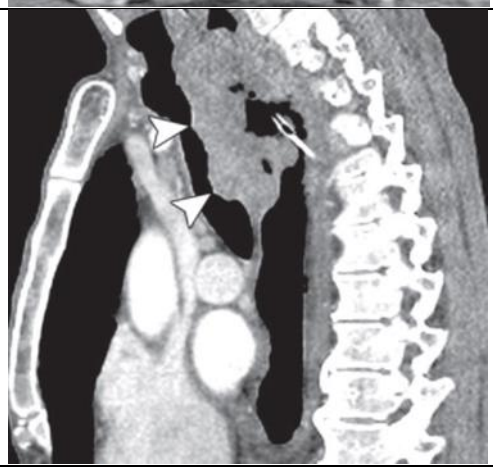
T3= eccentric mid-esophageal mass
N1= multiple enlarged periesophageal LNs



T3 N1 M0 (stage III)

Diffuse esophageal wall thickening + periesophageal fat infiltration .
Preservation of the fat plane (arrowheads) between mass and heart.
Preservation of the triangular fat space (arrow) between the esophagus, aorta, and spine adjacent to the primary tumor.
N1: Left gastric lymph node (arrow)



T4:	
• Diffuse wall thickening and narrowing of the left main bronchus (arrowheads). • Loss of the normal fat plane (arrows) between the esophagus and the thoracic aorta, a finding that is suggestive of aortic invasion.	
• Concentric thickening of the esophageal wall. • Contact of the tumor with > 90° of the aortic circumference (arrows) is concerning for aortic invasion. • Stranding of the adjacent fat (arrowhead) is consistent with mediastinal invasion	
• Mass that has invaded the posterior portion of the right side of the thyroid gland (arrowheads), • Bowing and displacement of the posterior wall of the trachea (arrow).	
• Tracheal Invasion.	

Vascular Impressions

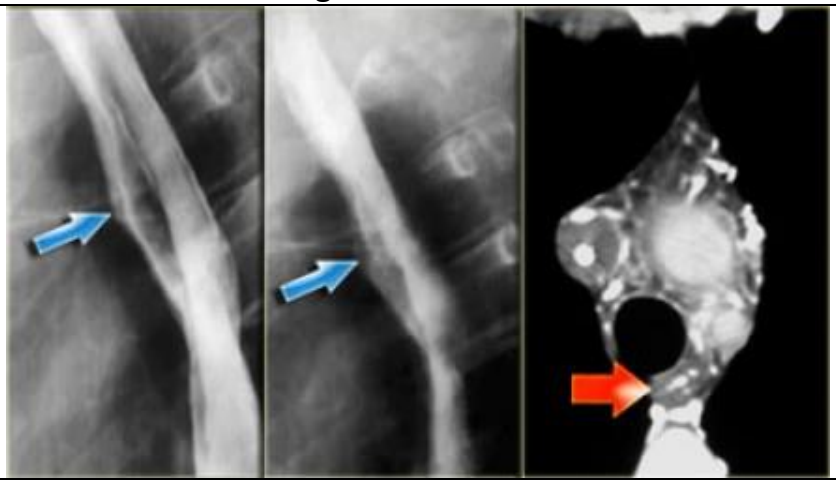
- Intrinsic
  - Uphill varices
  - Downhill varices
- Extrinsic
  - Aberrant right subclavian artery
  - Right aortic arch
    - Aberrant left subclavian artery type
    - Mirror image type
      - Does not affect esophagus
    - Isolated left subclavian type
  - Double aortic arch
  - Pathologic arteries and veins

1) Uphill Varices

- Portal hypertension, elevated portal venous pressure leads to reversed (hepatofugal) flow bypassing the liver through:
- Left gastric vein => dilated esophageal and periesophageal veins => anastamose with the azygos and hemiazygos veins => drain uphill into the superior vena cava.
- Filling defects due to varices are characterized by change in appearance during the examination related to breath holding and thoracic pressure.

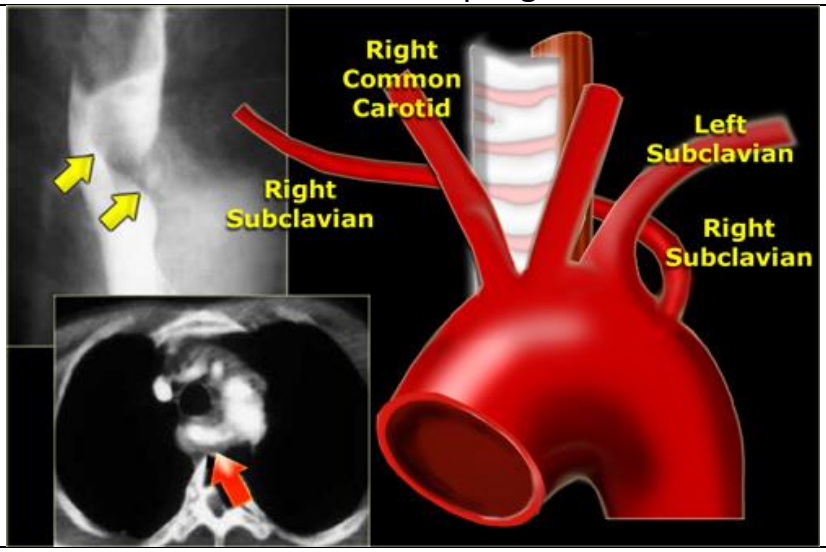
2) Downhill Varices

- Superior vena caval obstruction, upper body venous blood flows caudally downhill through esophageal veins to the azygos vein which empties into the superior vena cava caudal to the obstruction.
- If the obstruction is at or below the azygos, the blood flow extends further caudally to the portal system and then the hepatic veins to the inferior vena cava and the right atrium.



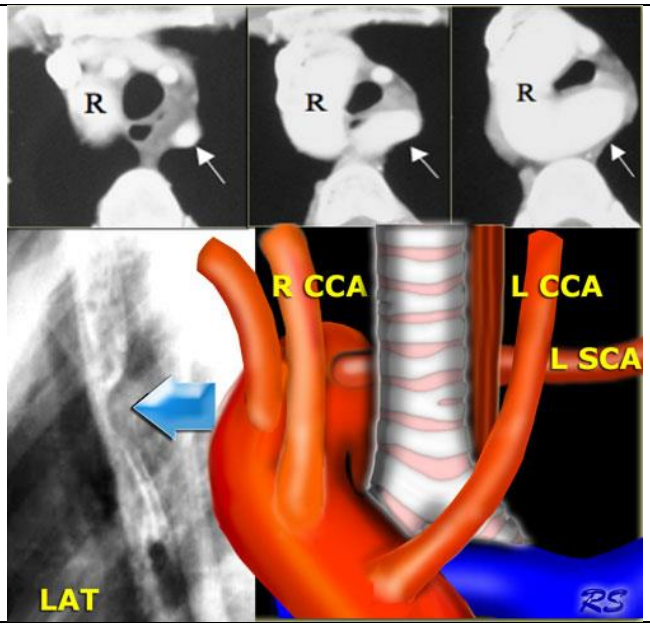
3) Aberrant Right Subclavian Artery

- This is the most common thoracic arterial anomaly and rarely causes symptoms.
- The artery extends up and to the right producing a dorsal diagonal impression on the esophagus (arrows).
- CT demonstrates that the aberrant artery (arrow) is last vessel from arch and extends dorsal to trachea and esophagus.



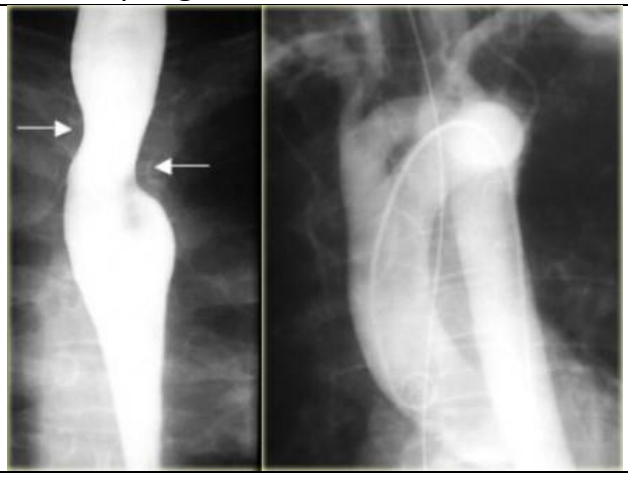
4) Right Aortic Arch With Aberrant Left Subclavian Artery

- A right aortic arch with an aberrant left subclavian artery is most often an incidental finding.
- A right aortic arch with mirror-image branching however is almost always associated with congenital heart disease.
- CT shows right arch (R) and aberrant left subclavian artery (arrow) arising low off arch and extending to left dorsal to esophagus and trachea.



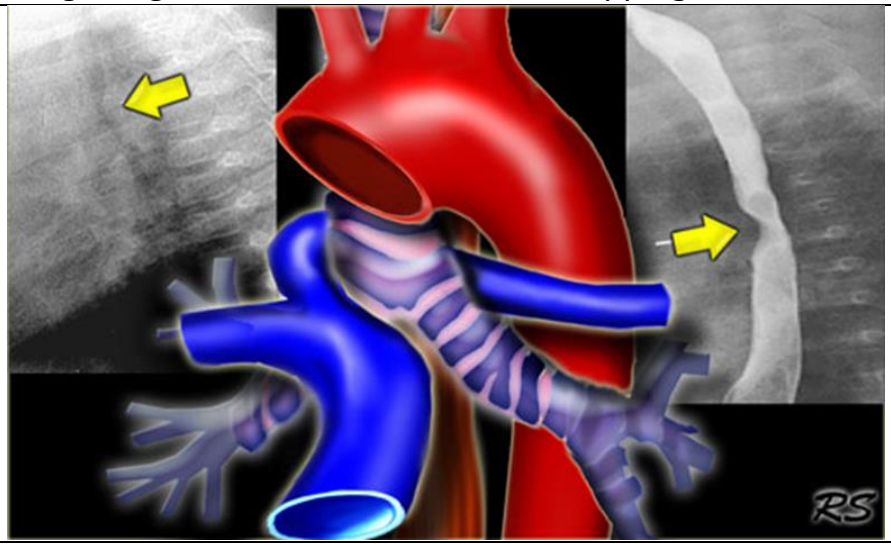
5) Double Aortic Arch

- Double arch most often presents with airway obstruction, dysphagia, and aspiration in children.
- The arches indent esophagus at different levels.



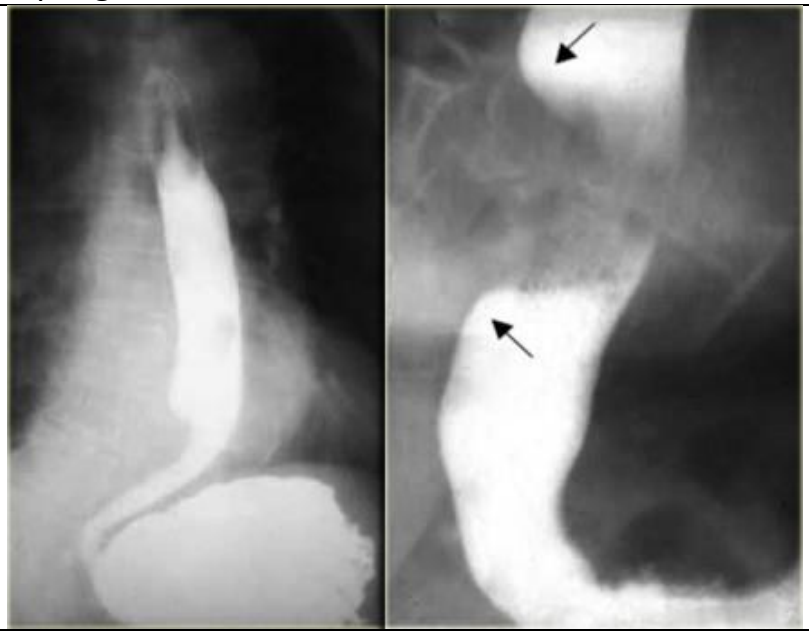
6) Aberrant Left Pulmonary Artery

- The aberrant left pulmonary artery indents the trachea dorsally and esophagus ventrally as it extends between them.
- Narrowing of right bronchus can cause air trapping or atelectasis.



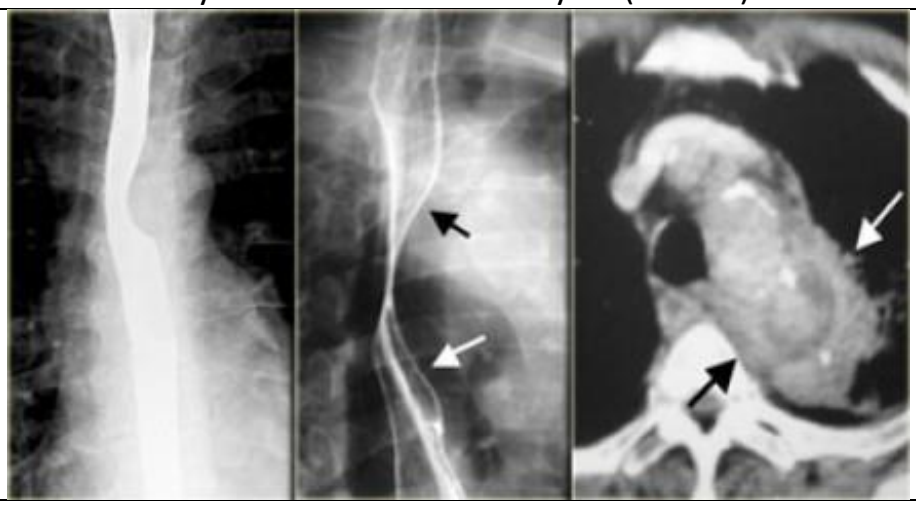
7) Tortuous Aorta

- A tortous descending aorta is a common cause of extrinsic impression on the esophagus.



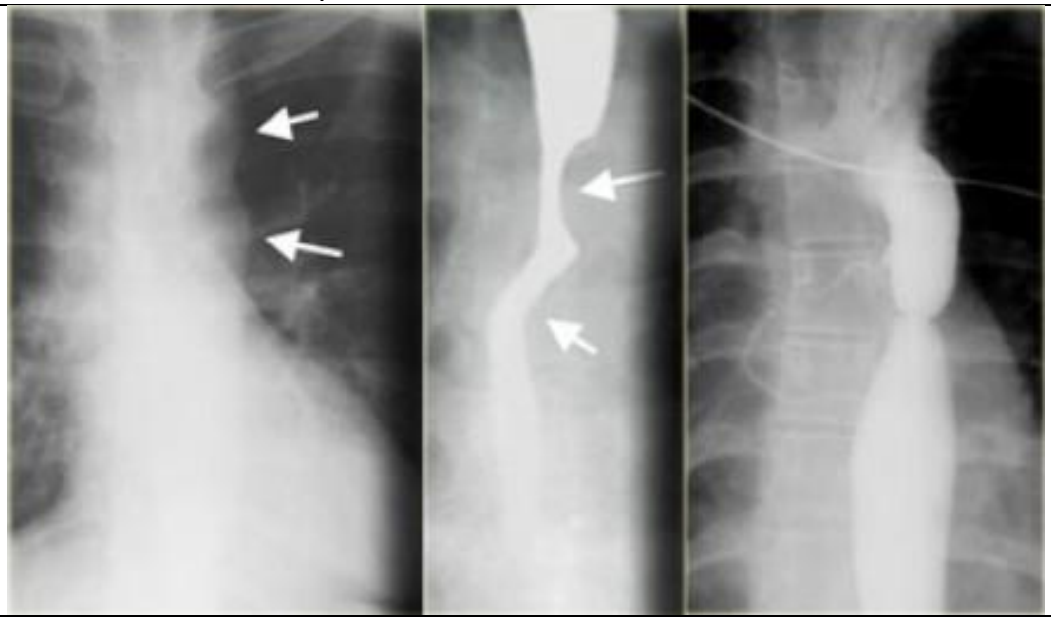
8) Aortic Pathology

On the far left the normal aortic arch impression on the esophagus.
This impression can be enlarged if there is dilatation of the aorta as seen in this patient with a mycotic aortic arch aneurysm (arrows).



9) Aortic Coarctation

- On the chest film the 'Figure 3' shape of aortic knob due pre and post stenotic dilatation (arrows).
- The barium study demonstrates the 'Reverse 3 figure' indention of esophagus by pre and post stenotic aortic dilatation (arrows).
- An angiogram demonstrates a coarctation with pre and post stenotic dilatation in another patient



Acute Esophageal Syndromes

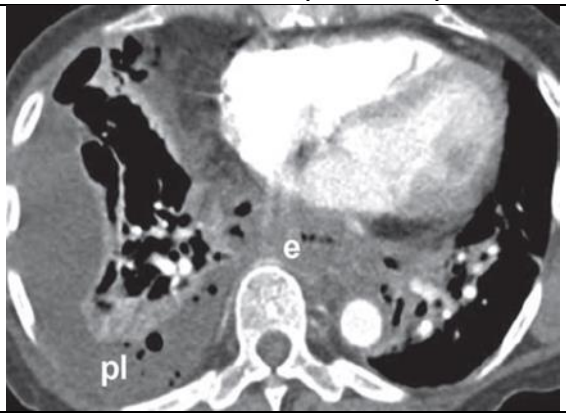
1) **Esophageal perforation**
2) **Boerhaave's Syndrome**
3) **Mallory Weis Tear**
4) **Esophageal Hematoma**
5) **Esophageal Dissection**
6) **Aorto-Esophageal Fistula**
7) **Esophago-Respiratory Fistula**

1) Esophageal Perforation

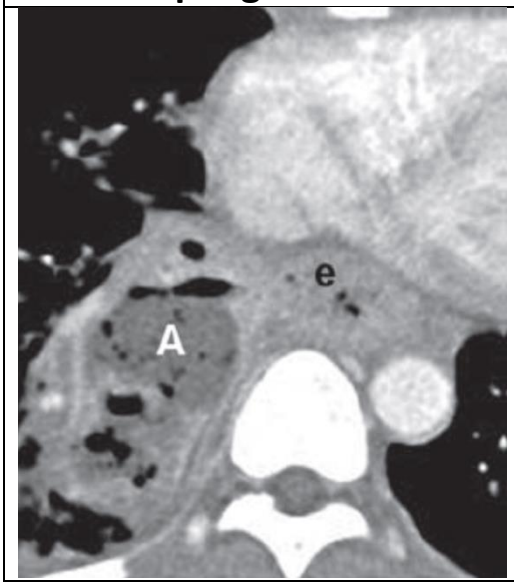
- Traumatic
    - Iatrogenic: surgical, endoscopic, or radiologic procedures
    - Ingestion of FB
- Neoplastic (eg, esophageal or lung cancers)
- Spontaneous (eg, Boerhaave syndrome)

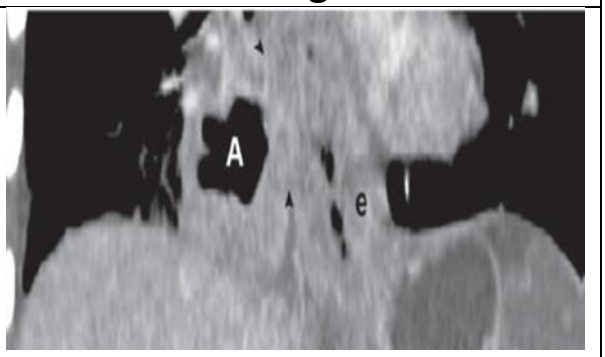
Imaging findings:

- Focal esophageal wall thickening.
- Periesophageal fluid collections.
- Free mediastinal air.
- Oral contrast extravasation into the mediastinum and pleural space



➢ **Esophageal Perforation => Rt lower lobe lung abscess**



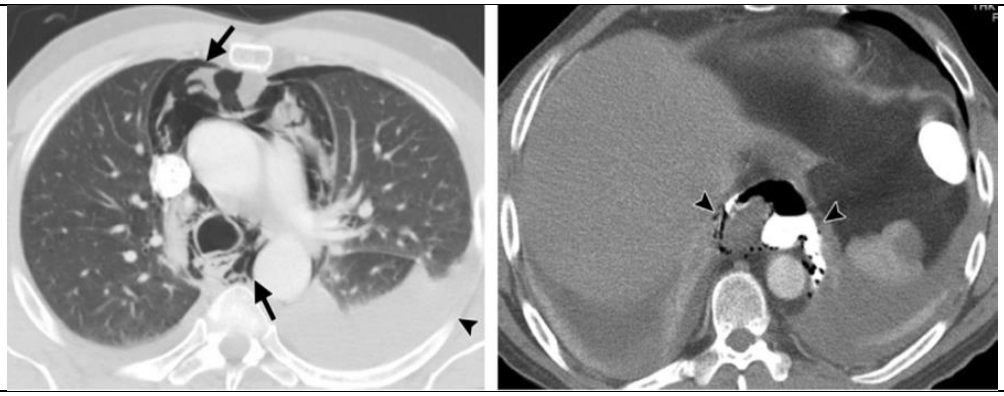


2) Boerhaave's Syndrome

- Boerhaave syndrome is defined as complete transmural laceration of the esophagus that results from violent straining or vomiting.

Imaging findings:

- Periesophageal air / fluid collections (arrow)
- Contrast extravasation (arrowhead) surrounding the distal esophagus
- Pneumomediastinum.



3) Mallory Weis Tear

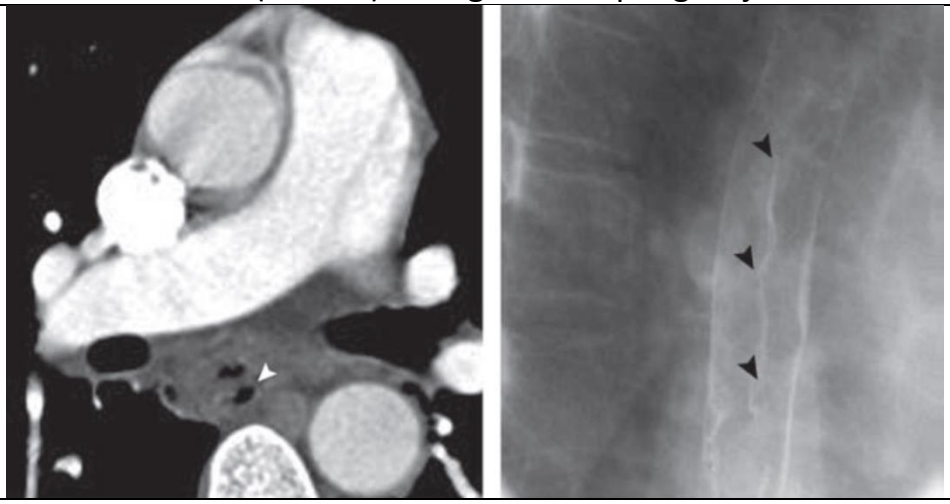
- ***Mucosal and submucosal tear without perforation.***

Cause:

- Vomiting
- Increased intra-luminal pressure: child birth, seizure, straining at defecation, weight lifting
- Hematemesis.

Barium swallow:

- Linear mucosal tear (arrows) near gastroesophageal junction.



4) Esophageal Hematoma

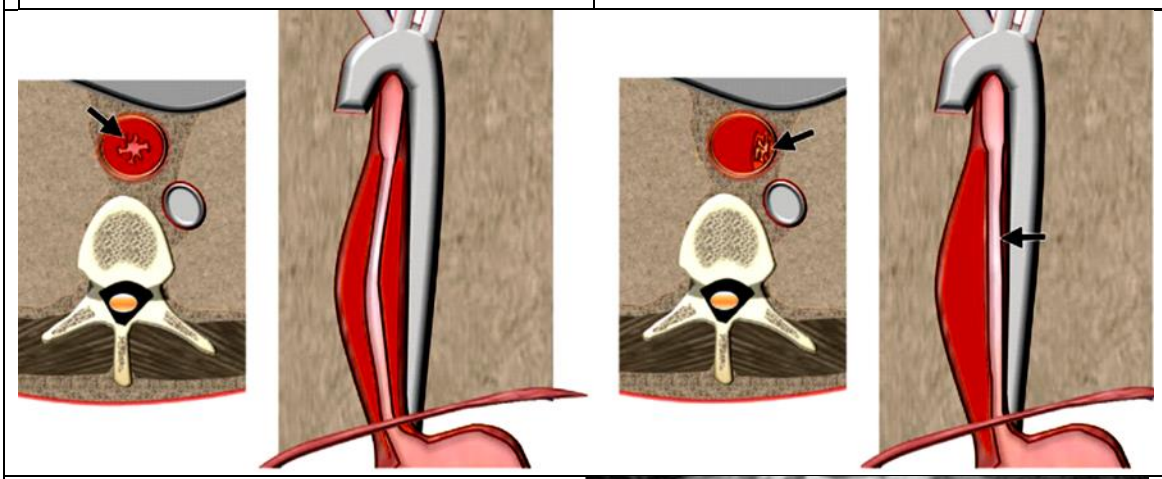
Clinical picture:

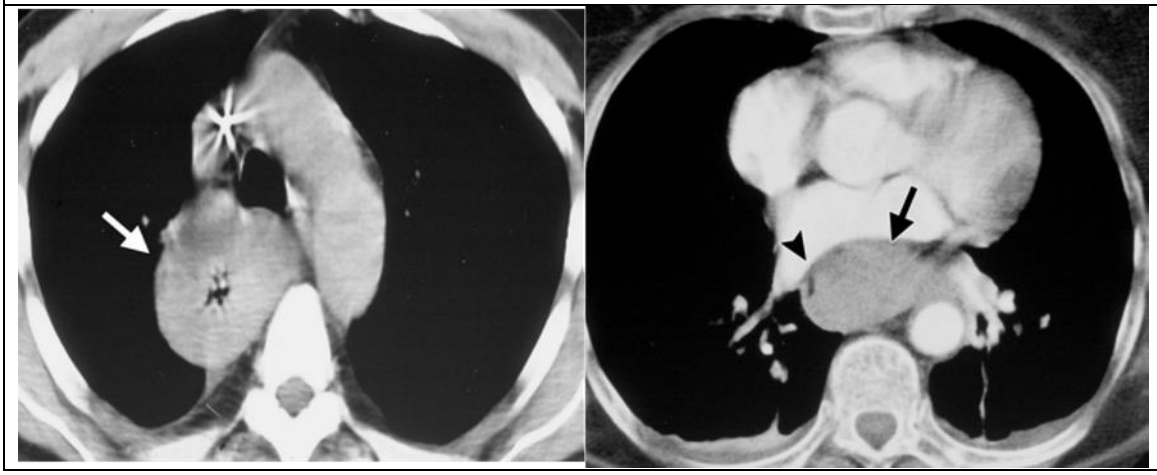
- Acute chest pain
- Hematemesis
- Dysphagia

Imaging findings:

- Symmetric or asymmetric esophageal wall thickening
- A well-defined, nonenhancing, high-attenuation intramural esophageal mass that extends along the esophageal wall.
- Luminal narrowing (in concentric type) & Luminal displacement (in eccentric type)

Concentric Mural hematoma	**Ecconcentric Mural hematoma**



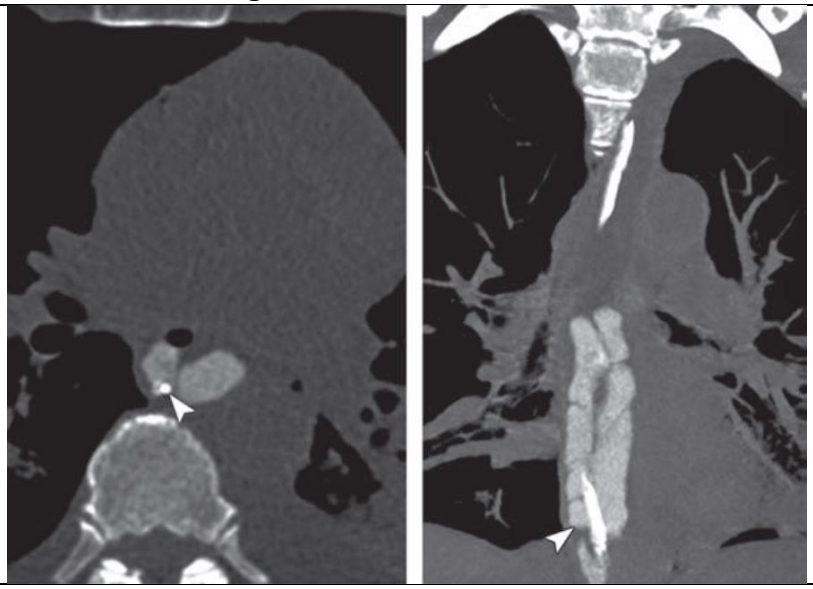


5) Esophageal Dissection

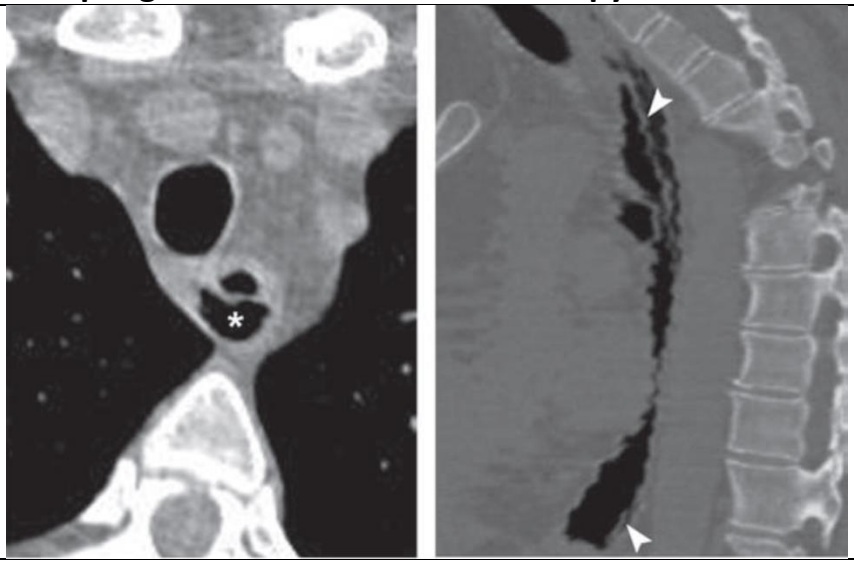
Clinical Symptoms:

- History of recent instrumentation.
- Abrupt onset of retrosternal chest pain
- Dysphagia or odynophagia
- Hematemesis

Esophageal double-barreled appearance = mucosal flap + Submucosal distribution of gas or oral contrast material

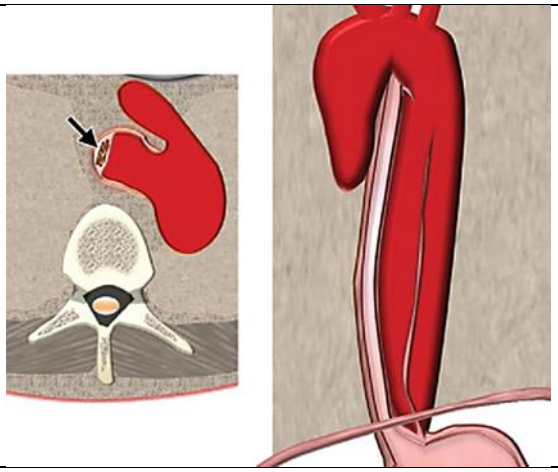


Intramural esophageal dissection after endoscopy

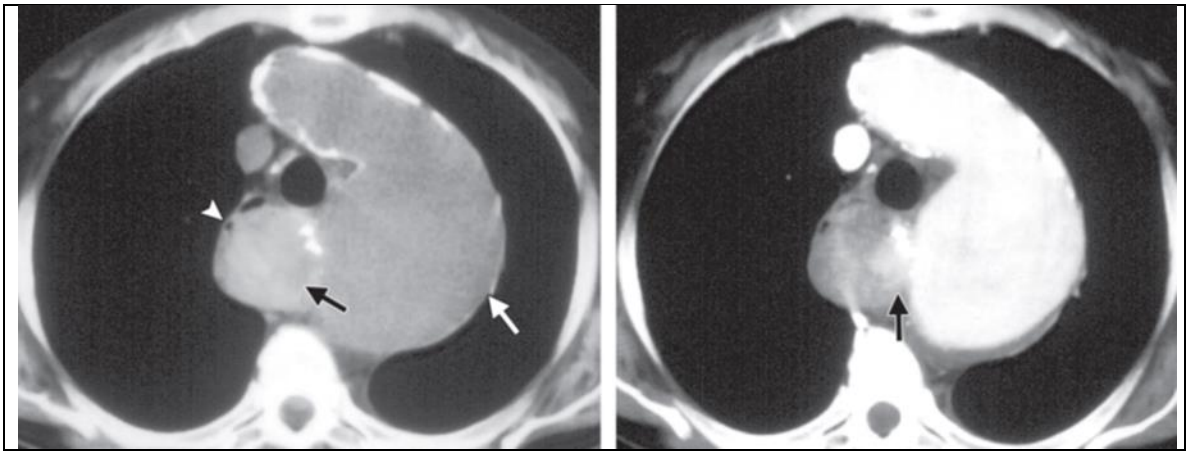


6) Aortoesophageal Fistula

- Aneurysmal dilatation of the thoracic aorta, which ruptures into the esophageal wall and leads to development of an intramural hematoma.
- The intramural hematoma displaces the esophageal lumen laterally (arrow).



NCCT:	**CECT:**
Hyperattenuating (66-HU) esophageal hematoma (black arrow) displacing the esophageal lumen laterally (arrowhead)	Fistulous tract from a penetrating aortic ulcer (arrow)



7) Acquired Esophago-Respiratory Fistula

- Fistulous communication may develop between the esophagus and the trachea, bronchi, or lung parenchyma;
- Tracheoesophageal fistulas are most common.

Benign causes:

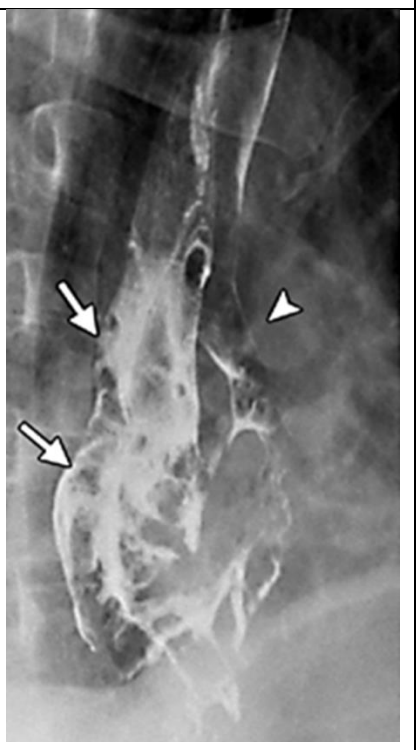
- Corrosive esophageal injuries,
- Prolonged intubation,
- Surgical or endoscopic procedures,
- Esophageal infection,
- Simultaneous rupture of mediastinal lymph nodes into the esophagus and airways,
- Ingestion of foreign bodies

Malignant causes:

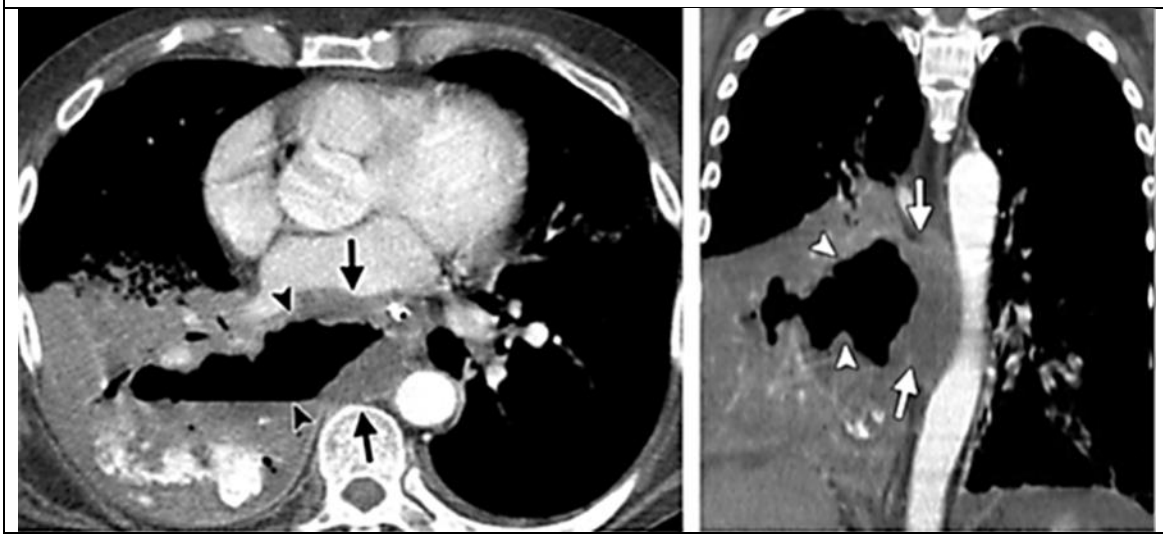
- Esophageal carcinoma.
- Bronchogenic carcinoma
- Lymphoma

Ba Swallow:

Oral contrast extravasation from esophagus into left bronchus.

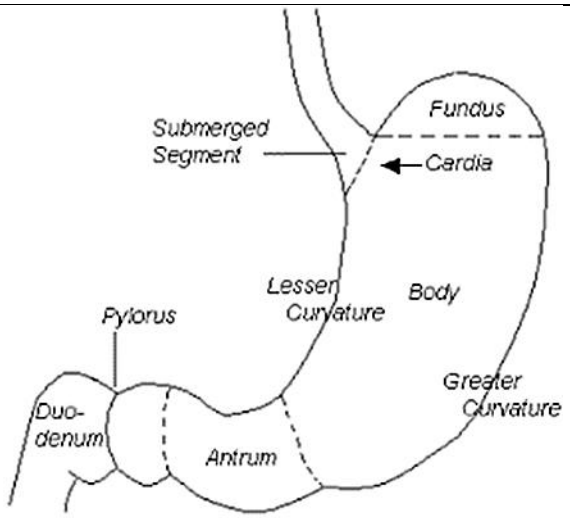


➢ ***Esophagopulmonary fistula secondary to esophageal carcinoma***



Stomach

Anatomy

<table>
<tr><td></td><td></td></tr>
<tr><td>Gross anatomy
The stomach (normal volume 45 ml) is divided into distinct regions:
• Cardia: the area that receives the oesophagus (gastro-oesophogeal junction)
• Fundus: formed by the upper curvature
• Body (corpus): the main central region of the organ
• Pylorus (antrum): the lower section of the stomach that facilitates emptying into the small intestine</td><td> 
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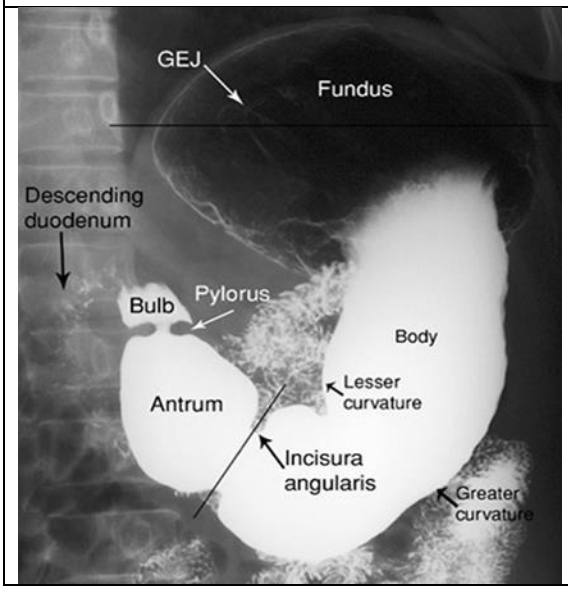
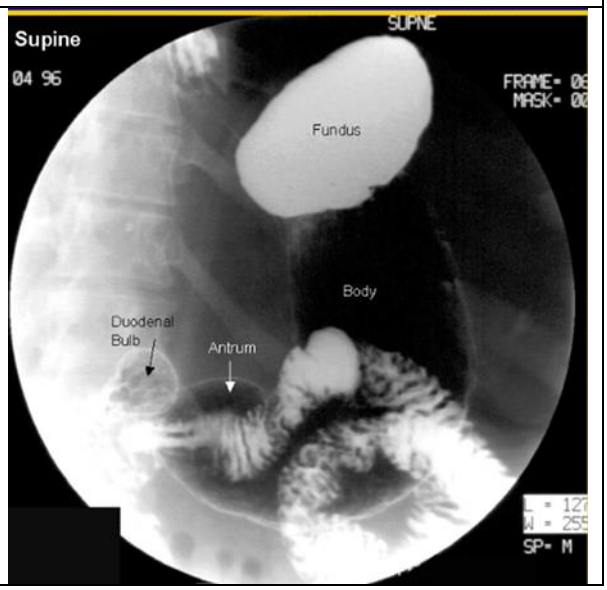
<tr><td>BA MEAL PRONE</td><td>BA MEAL SUPINE</td></tr>
<tr><td> 
</td><td> 
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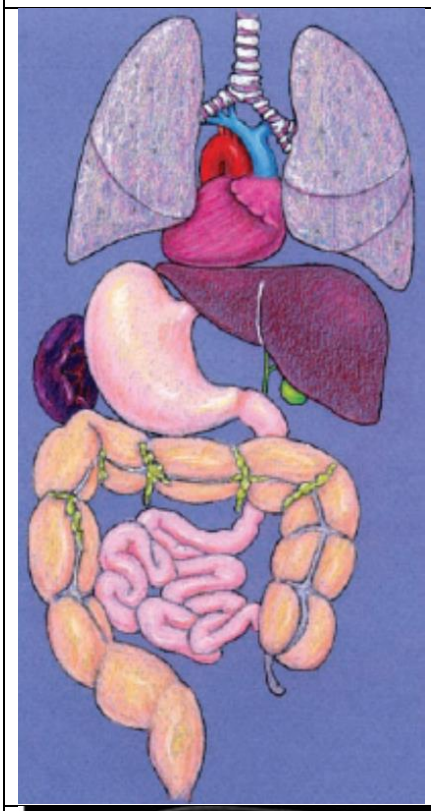
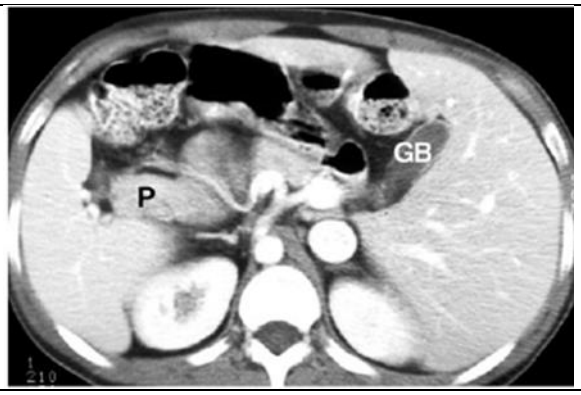
</table>

Gastric Anomalies

1) Situs Inversus Totalis

- Mirror-image location of the viscera relative to situs solitus.
- With the cardiac apex, spleen, stomach, and aorta located on the right and the liver and IVC located on the left.
- CHD occurs in 3%–5% of cases





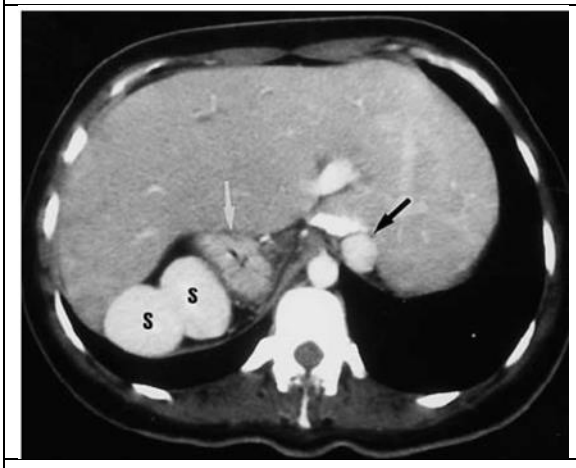
2) Situs Ambiguous with Asplenia

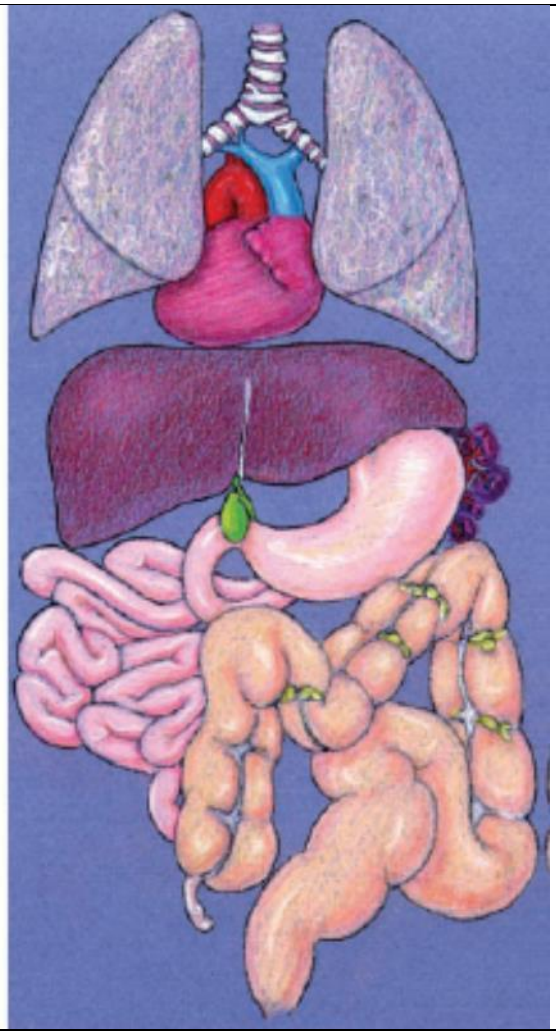
- Right isomerism or bilateral right-sidedness
- Ambiguous location of the abdominal organs
- Absence of the spleen
- CHD :- 99%–100%
- Much more severe than that seen with polysplenia and the other situs anomalies
- M>>f
- Death occurs in the 1st year of life in up to 95% (CHD + abnormalities in immune status)

a. b. c. d.

3) Situs Ambiguous with Polysplenia

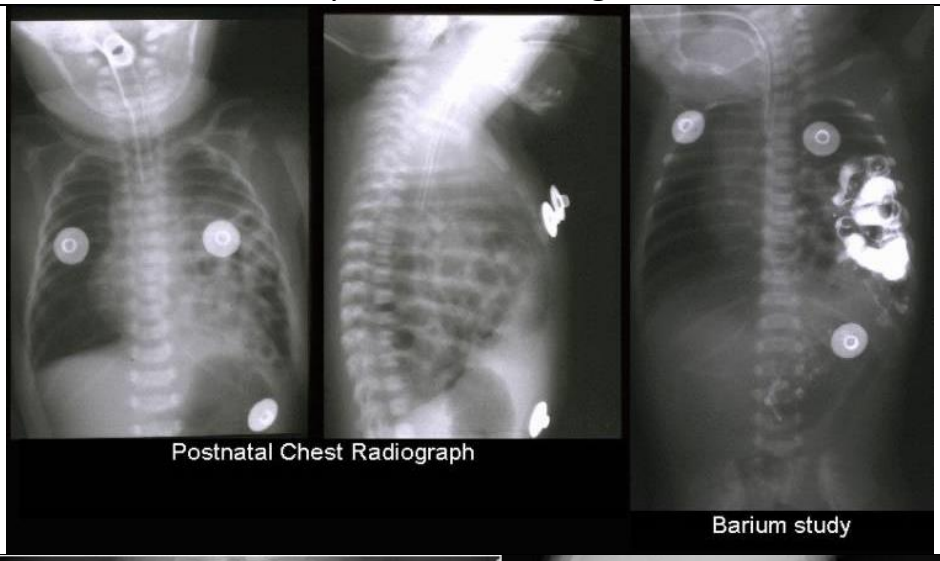
- Left isomerism or bilateral left-sidedness
- Midline or ambiguous location of the majority of the abdominal organs
- Multiple spleens
- CHD :- 50%– 90%

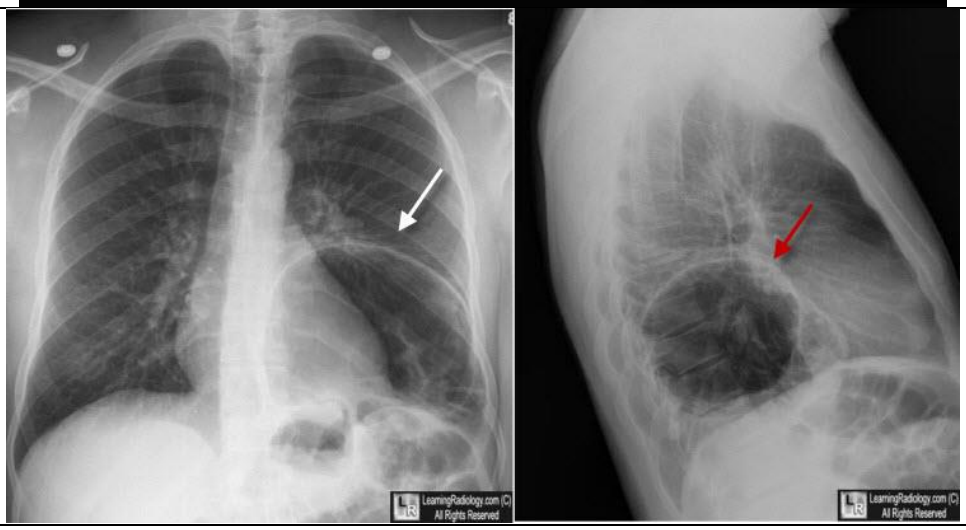




4) Congenital Diaphragmatic Hernia (Bochdalek's Hernia)

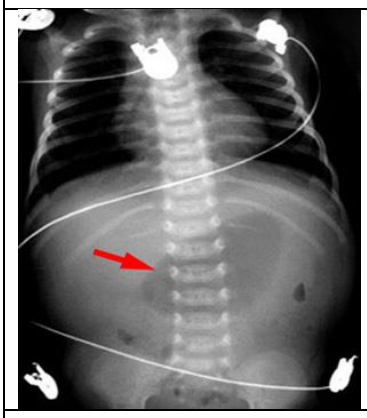
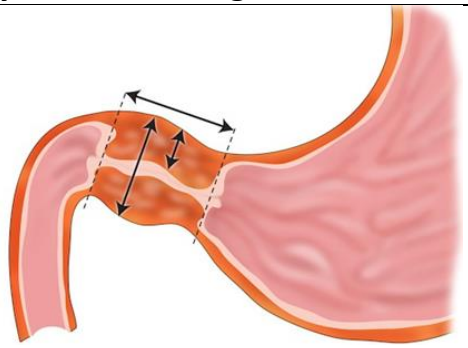
- Herniation through posterior pleuro-peritoneal hiatus into pleural cavity
- LT >>> RT
- Left sided hernias contain small intestine (88%), stomach (60%), colon (56%), liver (51%), gallbladder, spleen (45%), kidney (22%), pancreas (24%) or omental fat less commonly
- Right sided hernias usually contain liver or gallbladder



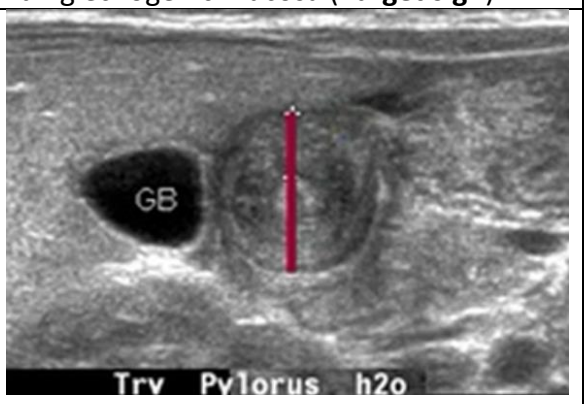


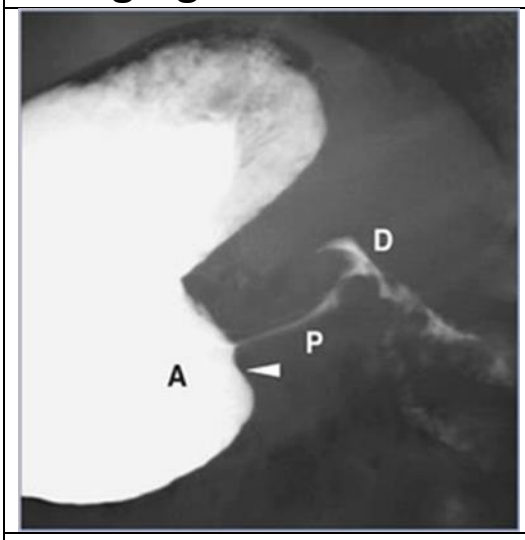
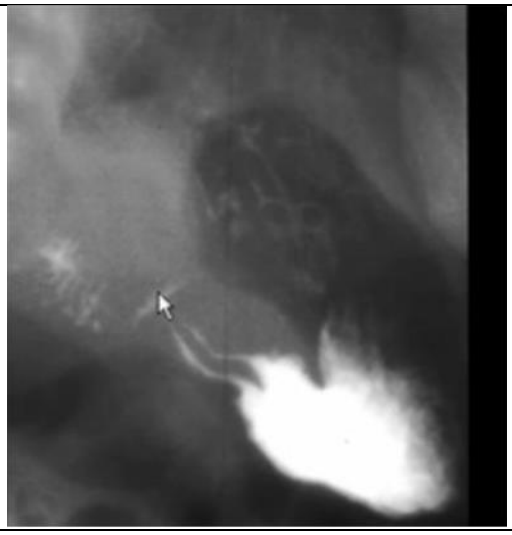
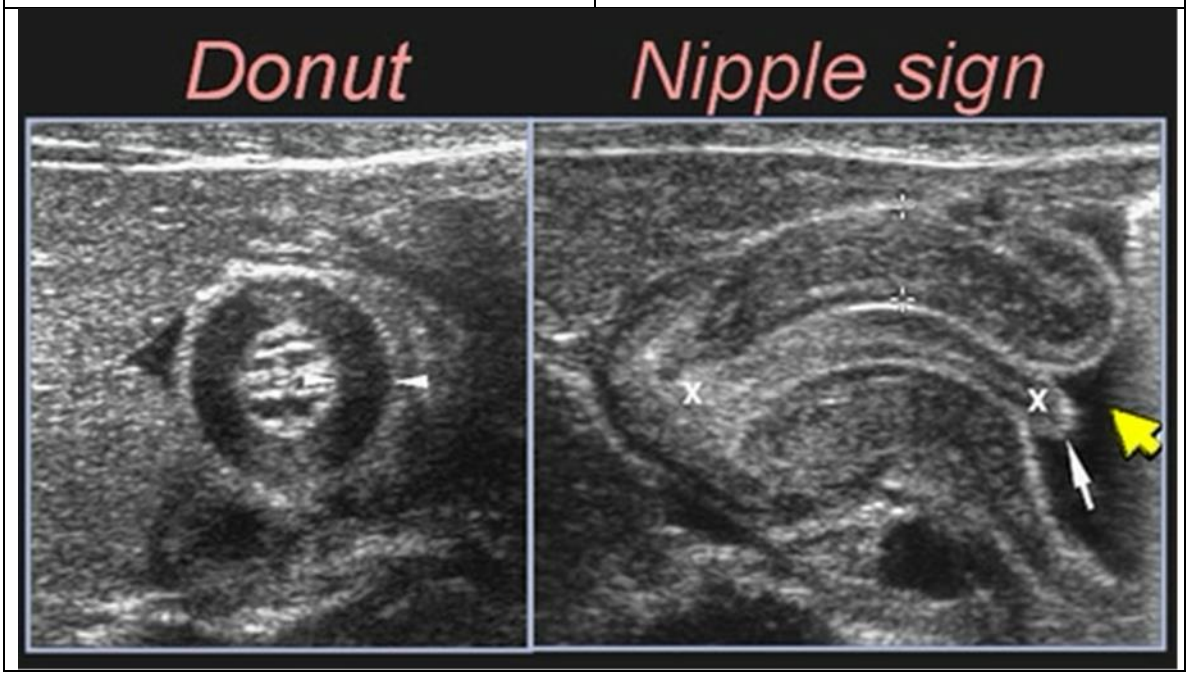
5) Infantile Hypertrophic Pyloric Stenosis

- Hypertrophy of the circular muscles of the pylorus
- Age: 3-6 weeks after birth
- Sex: M:F = 4:1
- Clinical Picture: Projectile non-biliary vomiting

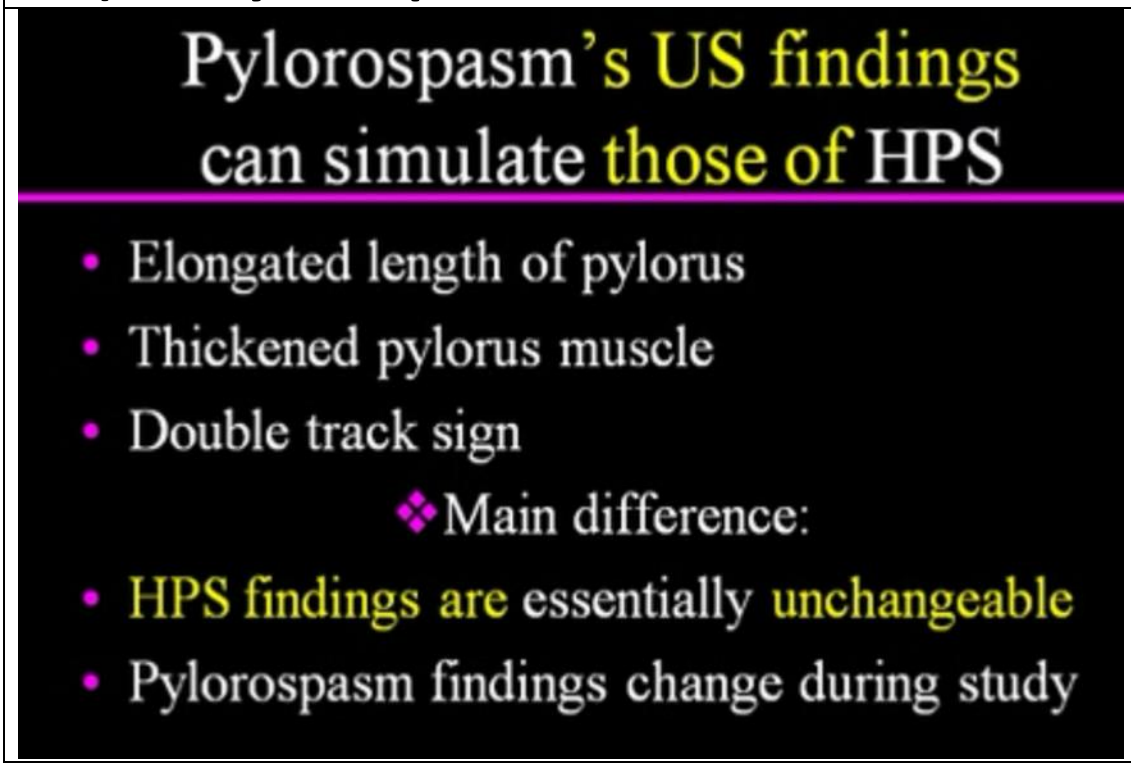
Plain X-ray	US
Single Bubble sign	**Muscle wall thickness > 3.5mm** **Total pyloric diamter > 15mm** **Pyloric canal length > 17mm**
	

- Delayed gastric emptying
- Elongated pylorus with a narrow lumen (**string sign**)
- Duplicated lumen due to puckering of the mucosa (**double-track sign**)
- Pylorus indents the antrum (**shoulder sign / Cervix sign**)
- Pylorus indents the base of the duodenal bulb (**mushroom sign**)
- Redundant pyloric mucosa protruding into the gastric antrum (**antral nipple sign**)
- Hypertrophied hypoechoic muscle surrounding echogenic mucosa (**Target sign**)

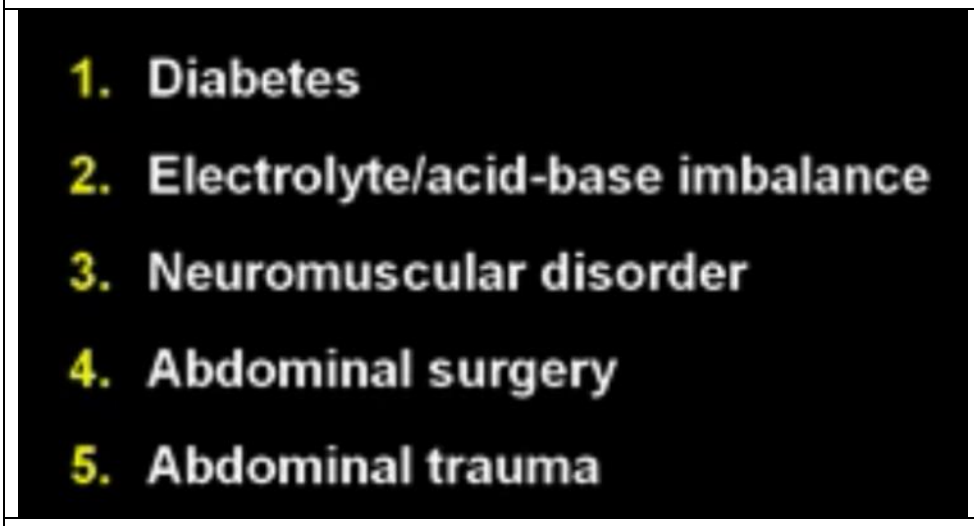


String sign	Double track sign
	
	

6) Pylorospasm


Pylorospasm's US findings can simulate those of HPS
• Elongated length of pylorus
• Thickened pylorus muscle
• Double track sign
❖ Main difference:
• HPS findings are essentially unchangeable
• Pylorospasm findings change during study

❖ Gastric Dilatation Without Outlet Obstruction



❖Gastric Outlet Obstruction:

Acquired	Congenital
○ Peptic Ulcer ○ Malignant ○ Bezor ○ Inflammatory disease	○ CHPS ○ Annular pancreas ○ Web ○ Antral diaphragm ○ Antral polyp ○ Volvus ○ Gastric duplication

❖Linitis Plastica

Neoplastic:

- Scriihous Gastric Carcinoma
- Lymphoma
- Sarcoidosis
- Amyloidosis

Inflammatory:

- Radiotherapy
- Tuberculosis
- Corrosive

❖Thickened Gastric Folds:

Inflammatory => Fundus & Body:

- Menetrier's disease
- Zollinger – Ellison Syndrome
- Crohn's disease

Neoplastic / Infiltration => Gastric Antrum:

- Lymphoma
- Carcinoma
- Eosinophilic gastritis
- Amyloidosis
- Sarcoidosis

Vascular:

- Watermelon Syndrome = Gastro-antral vascular ectasia = GAVE
- Fundal varices.

❖Bull's Eye = Target sign:

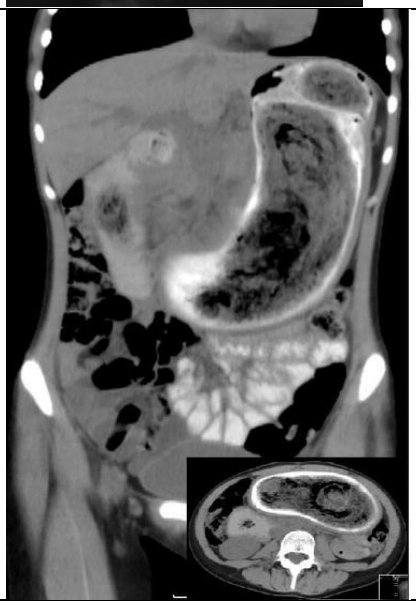
Submucosal tumor + Central Ulceration

- Leiomyoma
- Lymphoma
- Metastasis
- Neurofibroma
- Pancreatic rest

Gastric Bezoar

- Accumulations of undigestable contents with the gastrointestinal tract

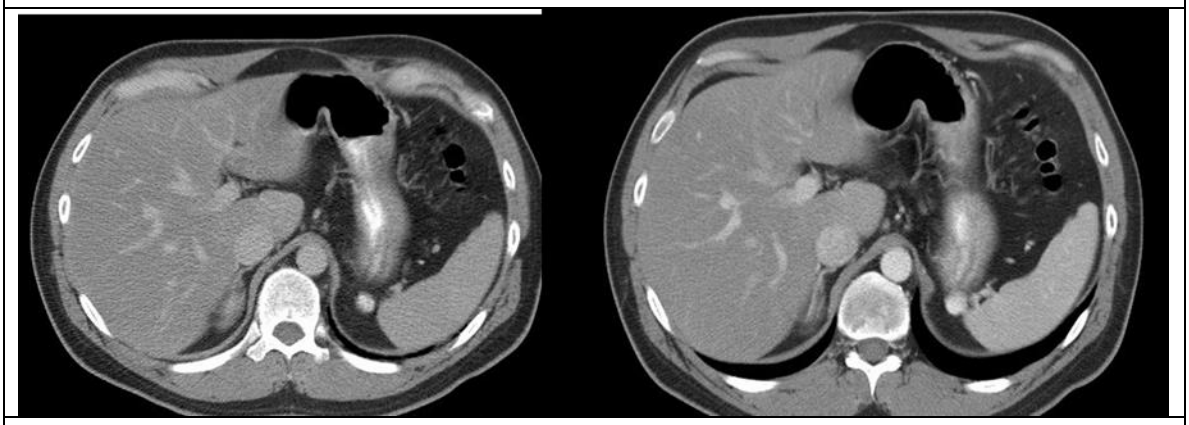
1) **<u>Trichobezoar:</u>** is a bezoar formed from hair.
2) **<u>Phytobezoar:</u>** are composed of indigestible food material (e.g. Cellulose) and are frequently reported in patients with impaired digestion and decreased gastric motility.
3) **<u>Pharmacobezoar:</u>** (or medication bezoars) are mostly undigested tablets or semi-liquid masses of drugs.
4) **<u>Lactobezoar</u>**: containing undigested milk curds



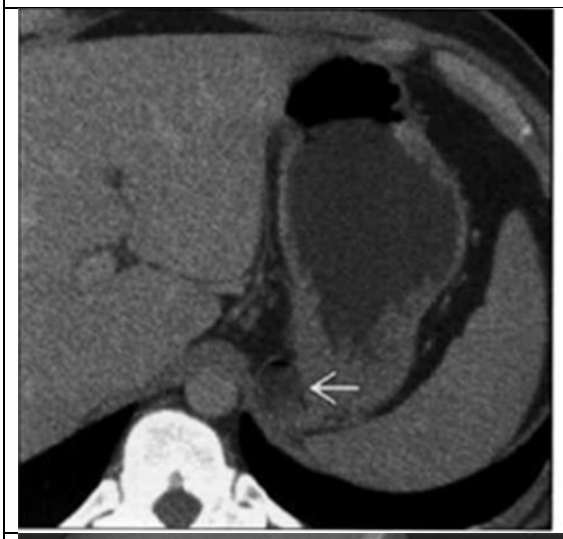
Gastric Diverticula

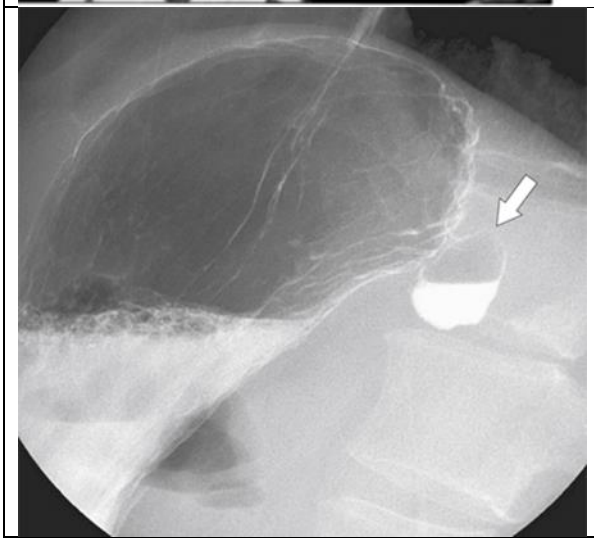
True Gastric Diverticula	Intramural or Partial Gastric Diverticula
○ Juxtacardiac ○ Posterior aspect of lesser curvature	○ Prepyloric ○ At greater curvature of the distal antrum
○ 1-3 cm, up to 10 cm ○ Barium-filled diverticulum with air-fluid level ○ Pooling of barium; mimics ulceration ○ Large gastric diverticulum fails to fill with gas or barium; mimics smooth submucosal mass ○ In antrum (rare); mimics ulcer craters	○ Tiny collection of barium extending outside the contour of the adjacent gastric wall; mimics ulcers ○ Movement of barium with peristalsis ○ Heaped-up area overlying diverticulum; mimics ectopic pancreatic rest on greater curvature

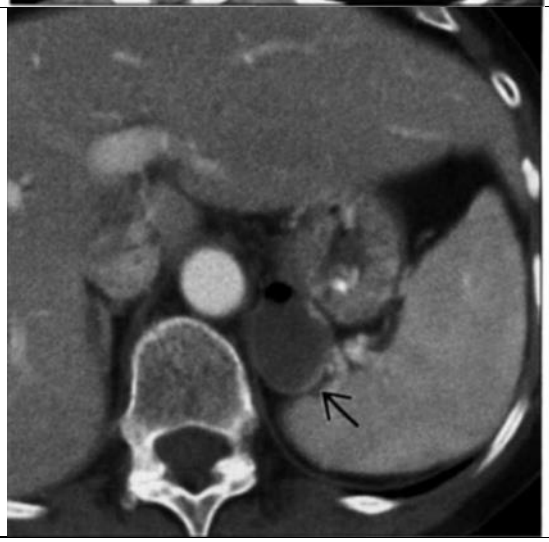
- **Gastric diverticulum filled with oral contrast**



- **Gastric diverticulum filled with air/fluid level**





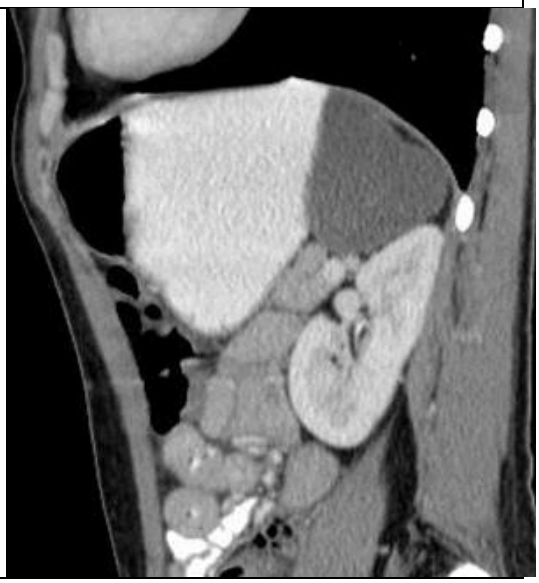


Gastric Duplication Cyst

- Rare congenital foregut duplication cyst affecting the stomach.
- < 10% of all gastrointestinal duplications.
- The most common site of gastrointestinal tract duplication cysts are the ileum, followed by oesophagus, large bowel and jejunum.

Imaging findings:

- Non-communicating cystic lesion in close contact with the stomach
- CT: Fluid attenuation
- T1: Low signal
- T2: High signal
- +C: No enhancement.



Peptic Ulcer

Predisposing factors:

- Helicobacter pylori infection
- Stress
- Burns=Curling ulcer
- Cerebral disease=Cushing ulcer
- Uremia
- NSAIDs
- Steroid therapy
- Hyperparathyroidism (25% have ulcer disease)
- Zollinger-Ellison syndrome

Complications:

- Upper GIT bleeding: Hematemesis / Melena
- Perforation: Acute abdominal Pain – peritonism
- Penetration: posterior wall ulcer penetrating to pancreas.
- Cauterization: fibrotic deformity secondary to healing ulcer:
  - Gastric: Pyloric stenosis – Gastric outlet deformity – Hour glass deformity – Shortening of the lesser curve
  - Duodenal cap: Trifoil (Clover leaf) deformity– Pseudo-diverticulae

Types of Peptic Ulcer:

- Acute peptic ulcer
- Chronic peptic ulcer

Location of Peptic Ulcer:

Gastric Ulcer Location

- 90-95% lesser curvature and posterior wall in gastric body and antrum
- ~5% Greater curvature

Duodenal Ulcer Location

- 95% bulbar ulcers
- 5% post-bulbar ulcers

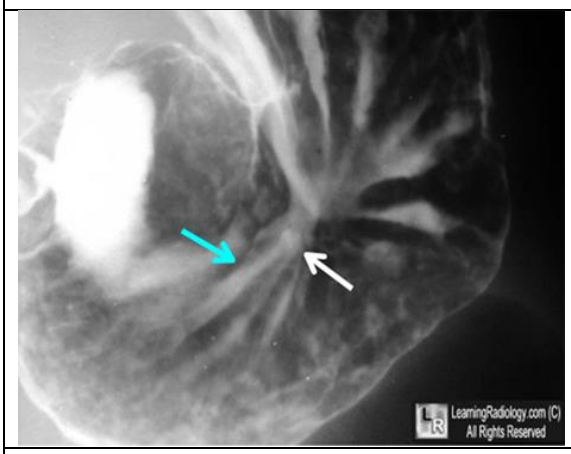
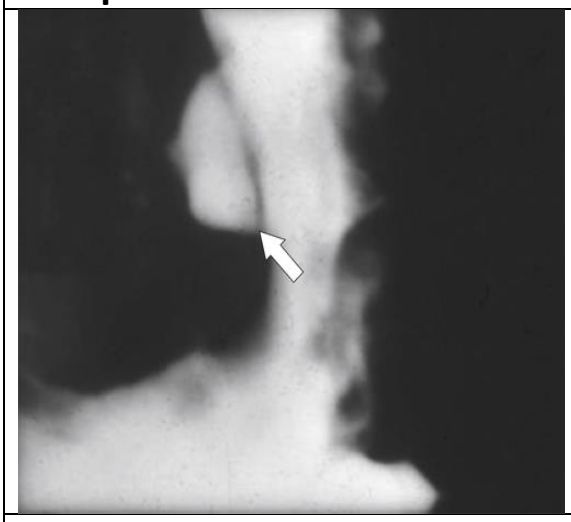
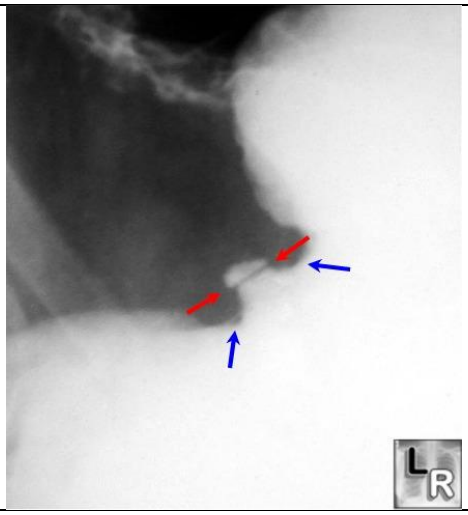
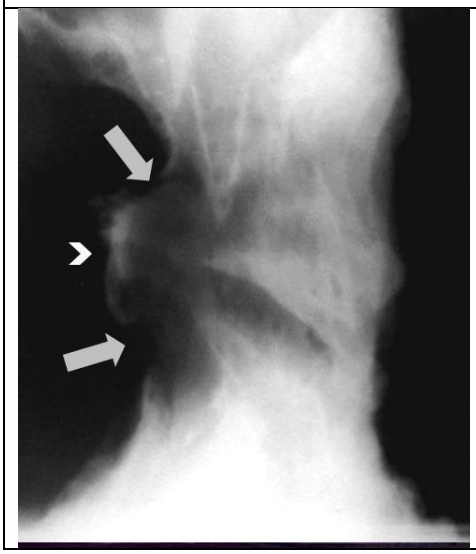
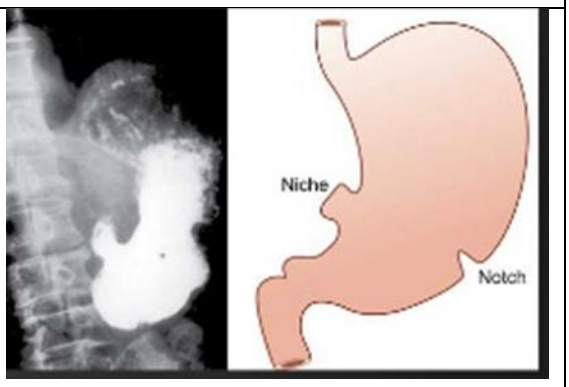
A- Acute Gastritis

- Predisposing factors: infection: H. pylori (most common) - Aspirin – NSAIDS - Stress – Toxemia – Septicemia – Drugs.
- Multiple small superficial gastric ulcers / erosions
- Surrounded by edematous hallo.
- Heal without scarring in 2-3 weeks of medical therapy.

B- Chronic Benign Gastric Ulcer

Barium Meal Imaging Findings

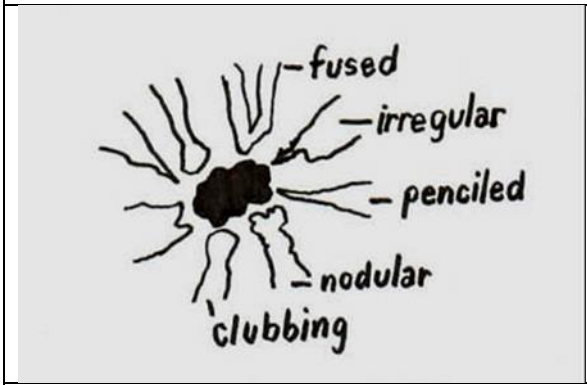
- **Ulcer crater or niche:**
  - Enface appearance: Round or ovoid persistent collection
    - Dependent ulcer: filled with barium
    - Non-dependent ulcer: barium coats the rim (ring shadow)
  - In profile appearance: ulcer extends beyond gastric wall
- **Ulcer brim:**
  - **Hampton line:** Thin radiolucent line separating barium in gastric lumen from barium in crater
  - **Ulcer collar:** Radiolucent rim of edematous mucosa around ulcer
  - **Ulcer mound:** Smooth, bilobed hemispheric mass projecting into lumen on both sides of ulcer.
- **Corona sign**: Smooth gastric folds radiating to edge of ulcer crater
- **Ulcer notch:** Incisura defect: Smooth or narrow indentation on greater curvature opposite an ulcer on lesser curvature (muscle contraction)

Ulcer crater enface	Ulcer crater in profile
	
Hampton Line	**Ulcer Collar**
	
Ulcer mound	**Ulcer notch**
	

C- Malignant Gastric Ulcer

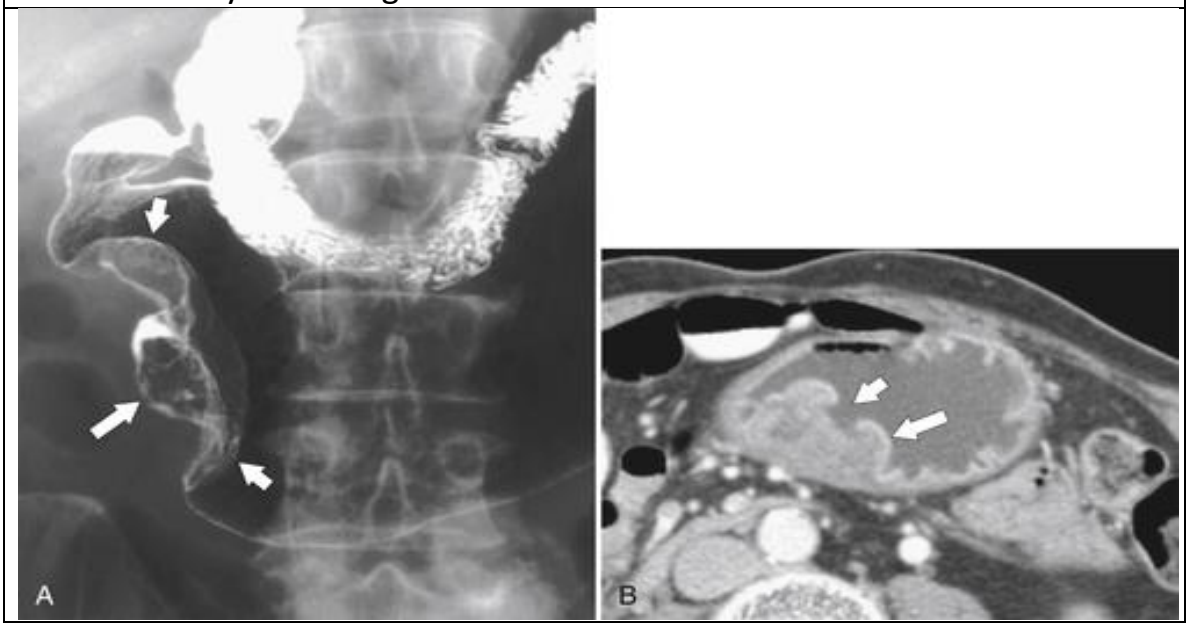
- Location: Greater curve and gastric antrum
- Not extend beyond gastric wall
- Project into gastric lumen
- Large ulcer: width > depth

Mucosal folds:



Carman meniscus sign:

- Crescent radiolucent shadow around ulcerating gastric cancer.
- Its concavity towards gastric wall.
- It convexity towards gastric lumen.



D- Duodenal Ulcer

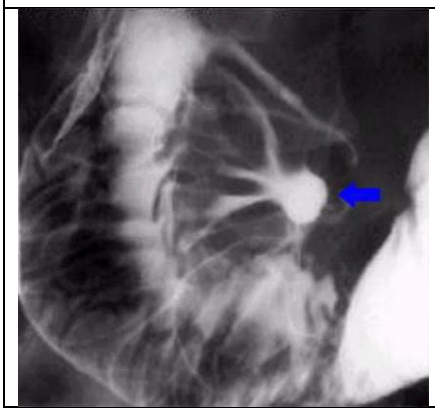
- 2-3 times more frequent than gastric ulcers
- 3:1 male:female ratio

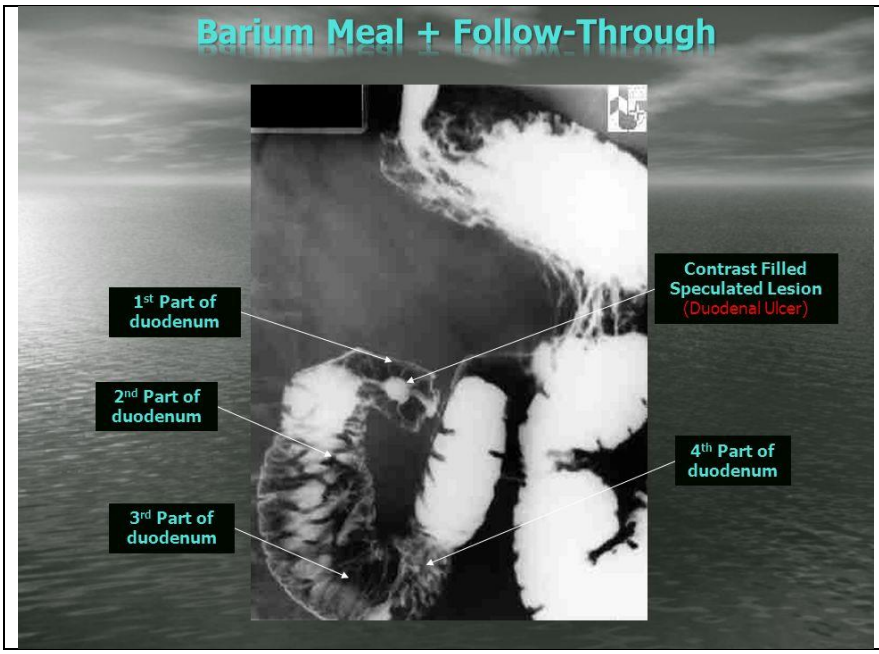
Location

- **Bulbar (95%)**
  - Anterior wall– 50%
  - Posterior wall– 23%
  - Inferior fornix– 22%
  - Superior fornix– 5%
- **Postbulbar (5%)**
  - Majority on medial wall just proximal to ampulla

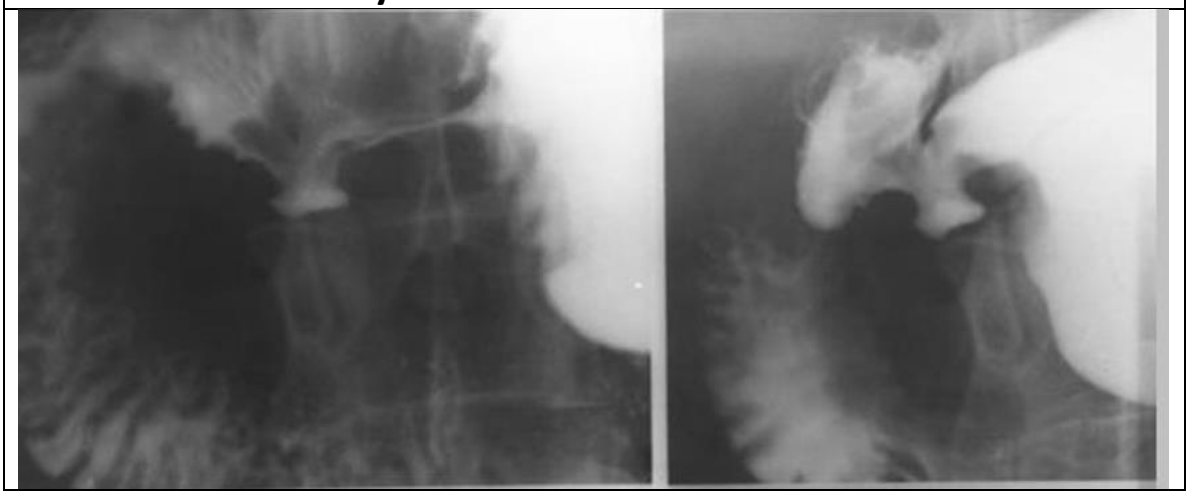
Posterior wall Duodenal Ulcer

Anterior wall Duodenal Ulcer




Barium Meal + Follow-Through
1st Part of duodenum
2nd Part of duodenum
3rd Part of duodenum
Contrast Filled Speculated Lesion (Duodenal Ulcer)
4th Part of duodenum

Clover leaf deformity of Duodenal Ulcer



Hypertrophic Gastritis

A- Menetrier Disease

- RARE ; Hyperproliferative protein-losing gastropathy
- Leads to protein loss and hypoproteinemia

Bimodal age distribution:

- **Childhood form:**
  - often linked to cytomegaloviral infection
  - Usually resolves spontaneously. It
  - Children younger than 10 years
  - M:F = 3:1
- **Adulthood form:**
  - The disease in adults tends to progress over time.
  - The average age at diagnosis is 55
  - M > F

Clinical Presentation:

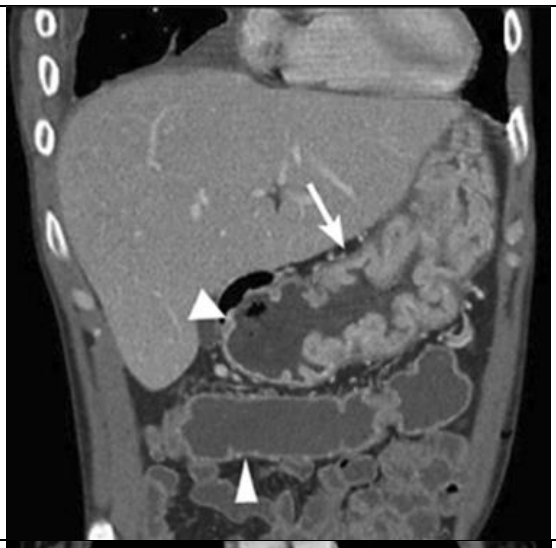
- Abdominal pain, nausea, vomiting

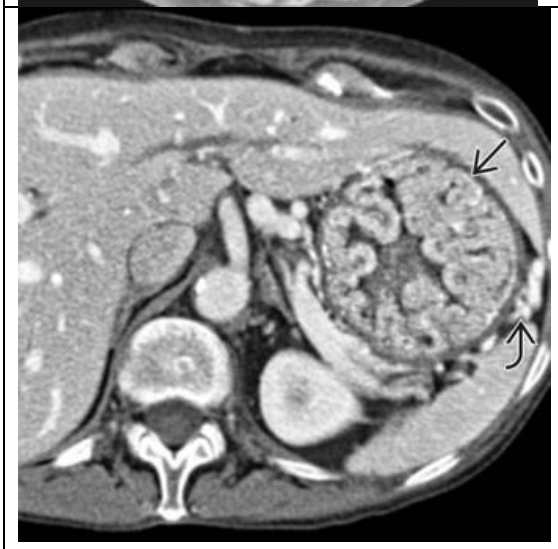
Imaging findings:

- Grossly thickened, lobulated folds in the proximal of stomach = gastric fundus & body + Greater curve; relative sparing of antrum
- Giant, mass-like elevation of folds on greater curvature; relative sparing the lesser curvature (different from lymphoma).
- No extension to the perigastric tissue.
- Excessive gastric mucus secretion into the gastric lumen => dilute barium => poor barium coating
- Stomach remains pliable & distensible (DD: linitis plastica)

Generalized manifestation of hypoproteinemia and hypoalbumenia:

- Ascites – Pleural effusion – Generalized edema





B- Zollinger-Ellison Syndrome

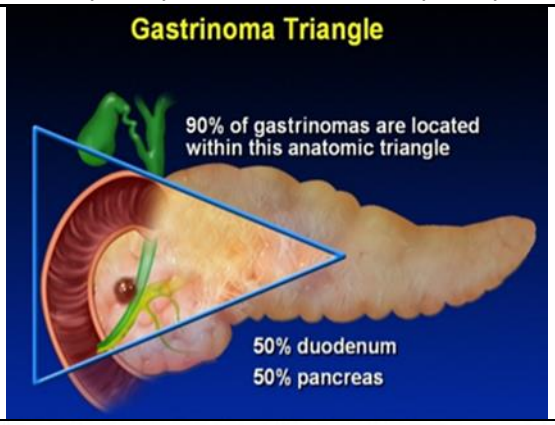
- Severe peptic ulcer disease associated with marked increase in gastric acid due to gastrin producing islet cell tumor (gastrinoma) of pancreas

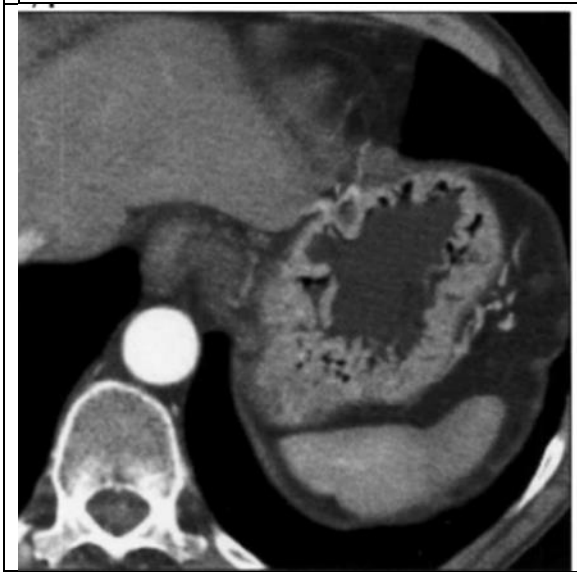
Gastrinoma

- Hypervascular pancreatic mass
- Multiple peptic ulcers & thickened folds
- Gastrinoma: Pancreas (75%); duodenum (15%); liver & ovaries (10%)

Clinical Tetrad:

1) Gastric Hypersecretion
2) Diarrhea or steatorrhea
3) Hyperacidity-elevated serum gastrin levels
4) Recurrent peptic ulcer disease





Atrophic Gastritis

- Chronic condition of autoimmune and non-autoimmune aetiology.

Type A: Autoimmune

- Gastric body and fundus atrophy secondary to antiparietal cell antibodies
- Decreased secretion of acid and intrinsic factor => Vitamin B12 deficiency

Type B: Non-Autoimmune (more common)

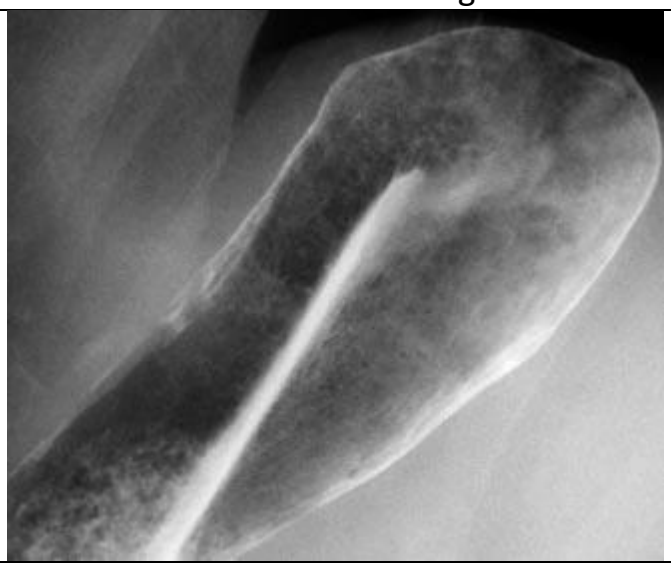
- Gastric antrum atrophy secondary to Helicobacter pylori infection (most common), alcohol, NSAID use, or bile salt reflux

Associations

- Vitamin B12 deficiency
    - Pernicious anaemia (megaloblastic)
    - Subacute combined degeneration of the cord
- Gastric carcinoid tumours

Imaging findings:

- Absent rugal folds in upper stomach cause "bald fundus" sign.



Eosinophilic Gastroenteritis

- is a disease of unknown etiology characterized by eosinophilic infiltration of the GI tract in the absence of other causes of eosinophilia.
- Patients typically present with failure to thrive, abdominal pain, irritability, diarrhea, and dysphagia.
- Symptoms will vary depending on the segment of intestinal tract involved.
- 10% of cases are familial and up to 75% of patients are atopic.
- Many patients report seasonal allergies, food sensitivities, and asthma: suggesting hypersensitivity contributes to pathogenesis.
- Several disorders must be excluded before the diagnosis of eosinophilic gastroenteritis can be suggested.
- Differential includes: drug hypersensitivity, collagen-vascular disease, malignancy, infection, gastroesophageal reflux disease, inflammatory bowel disease, esophageal leiomyomatosis, allergic vasculitis, scleroderma, myeloproliferative disorders, and hypereosinophilic syndrome (HES).
- HES presents with severe sustained peripheral blood eosinophilia (>1500 cells/mm2) and the presence of end-organ involvement, such as cardiomyopathy or CNS involvement.

Imaging findings:

- Eosinophilic esophagitis commonly demonstrates => Ringed esophagus = series of ring like strictures)
- Ggastroentestinal envolvemnt is more common(virtually always involves gastric antrum and proximal small intestine),non spesific mucosal fold thickening and nodularity particullarly in gastric antrum w/wout submucosal edema, when chronic, the antrum is narrowed with a nodular "cobblestone" mucosal appearance

Emphysematous Gastritis

- A condition involving gastric wall inflammation,
- Radiological evidence of intramural gas, and systemic toxicity.
- Caused by mucosal disruption characterized by gas in the stomach wall.
- Corrosive ingestion; trauma or gastric infarction.
- Organisms most commonly involved are escherichia coli, streptococcus species, enterobacter species, and pseudomonas aeruginosa.

DD of Gastric intra-mural Gas:

A) Non-Infectious: Interstitial Gastritis

- = gas accumulation in submucosa/subserosa/or both
- Intramural gas tends to be sharply defined and linear.
- Some patients may have recently undergone a gastric procedure.

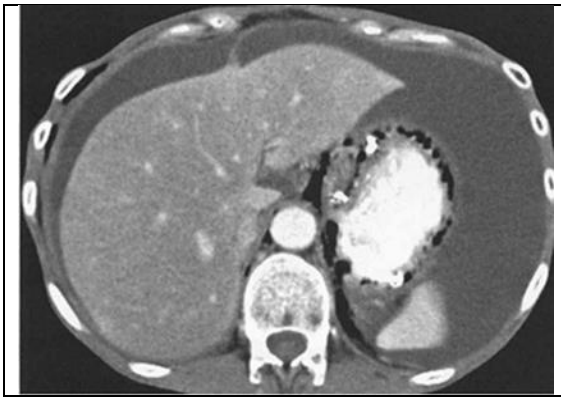
B) Air from Extrinsic Source

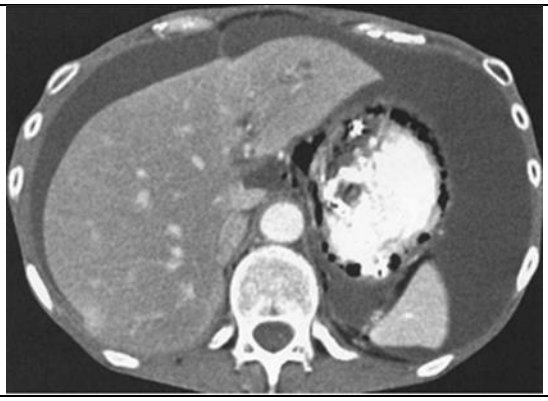
- Obstructive (due to raised intragastric pressure):
- Gastric outlet obstruction, volvulus, overinflation during gastroscopy, profuse severe vomiting
- Pulmonary (due to rupture + dissection of subpleural blebs in bullous emphysema along esophageal wall/mediastinum): pulmonary emphysema
- Traumatic (due to mucosal trauma):
- Instrumentation of stomach, recent gastroduodenal surgery, endoscopy (1.6%)
- Linear lucency conforming to contour of a thinwalled distended stomach
- Cystic pneumatosis
- = PNEUMATOSIS CYSTOIDES INTESTINALIS

C) INFECTIOUS

- Emphysematous gastritis

- A protocol of early treatment with a broad-spectrum antibiotic and surgical revascularization performed immediately after diagnostic angiography has been reported to successfully reverse gastric ischemia.





Alcoholic Gastritis

- Generalized thickening of folds
- usually subsides after withdrawing of alcohol.
- Bizarre thickening may mimic malignant disease.
- There is a relative absence of folds in chronic alcoholic gastritis

Gastric Tumors

A- Gastric Adenocarcinoma

- 4th most common cancer worldwide.
- 3rd most common GIT malignancy after colorectal & pancreatic carcinoma

- Histopathology: Adenocarcinoma (95%)

Environmental factors have major role in development of gastric cancer

- Helicobacter pylori (3-6 fold 1 risk)
- Pernicious anemia (2-3 fold 1 risk)

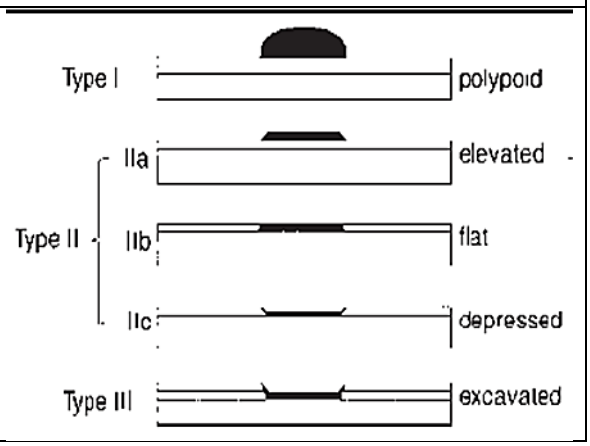
5-year survival rate:

- Early gastric cancer (EGC) 5-year survival rate = 85%–100%.
- Advanced gastric cancer (AGC) 5-year survival rate = 7%–27%

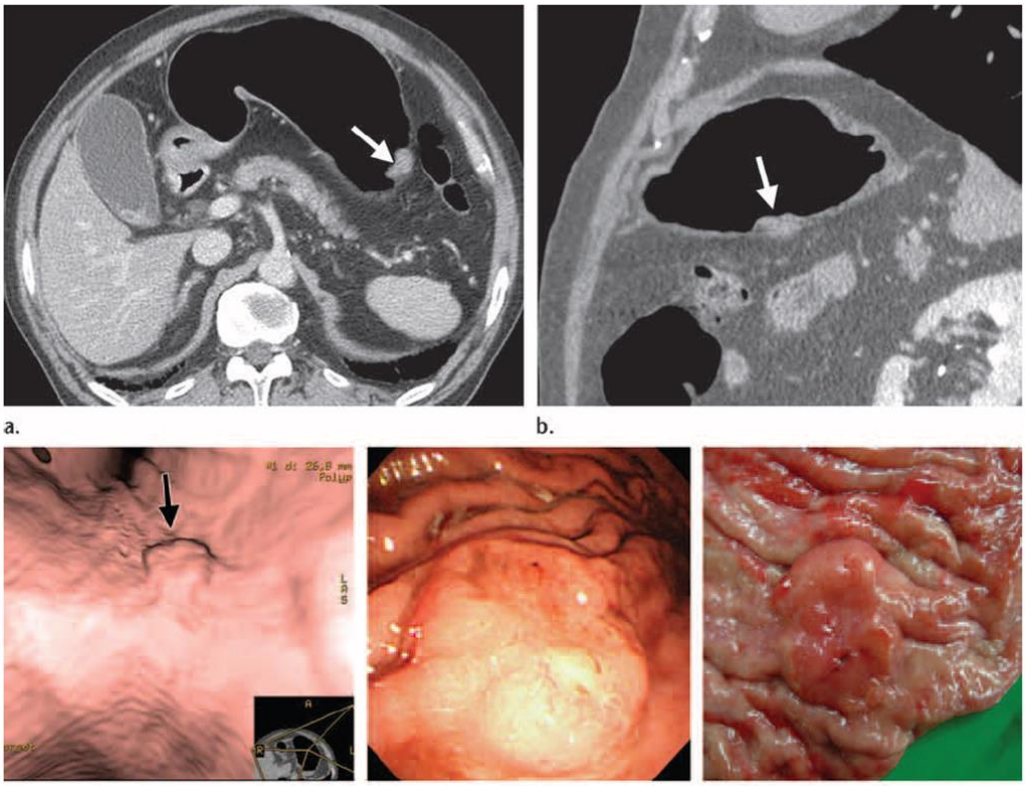
❖Early Gastric Cancer (EGC)

Japanese Morphological Classification

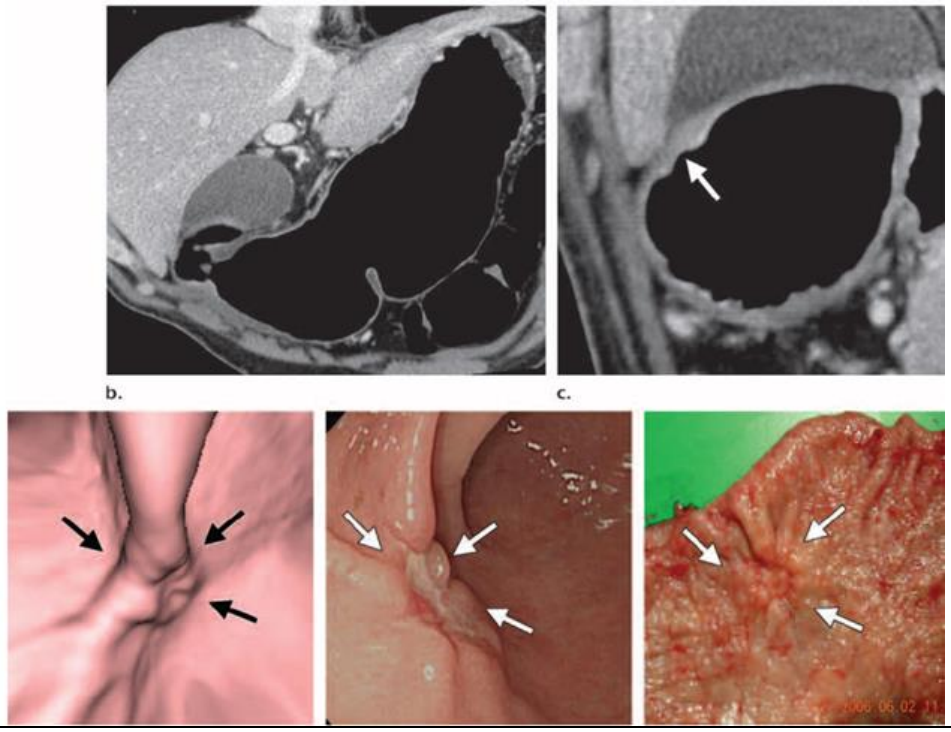
Type	Description
I	Polypoid lesions (ie, elevated lesions that protrude >5 mm into the lumen)
IIa	Superficial elevated lesions that protrude <5 mm into the lumen
IIb	Superficial flat lesions
IIc	Superficial depressed lesions that do not penetrate the muscularis mucosa
III	Excavated lesions (ie, true mucosal ulcers that penetrate the muscularis mucosa but not the muscularis propria)



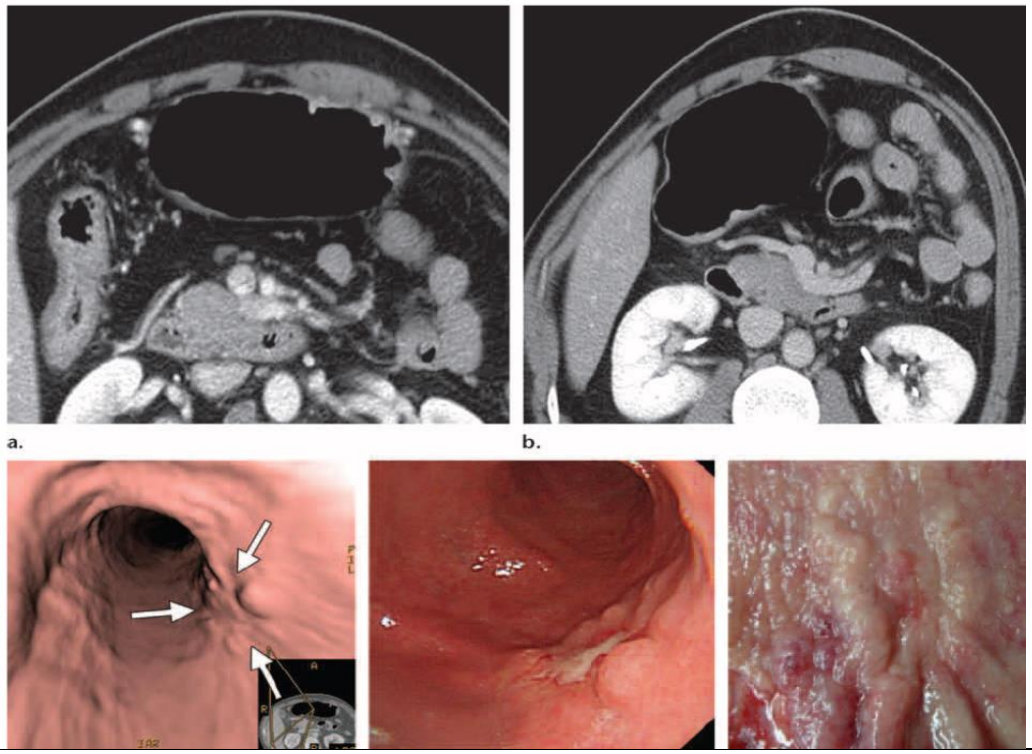
Type I



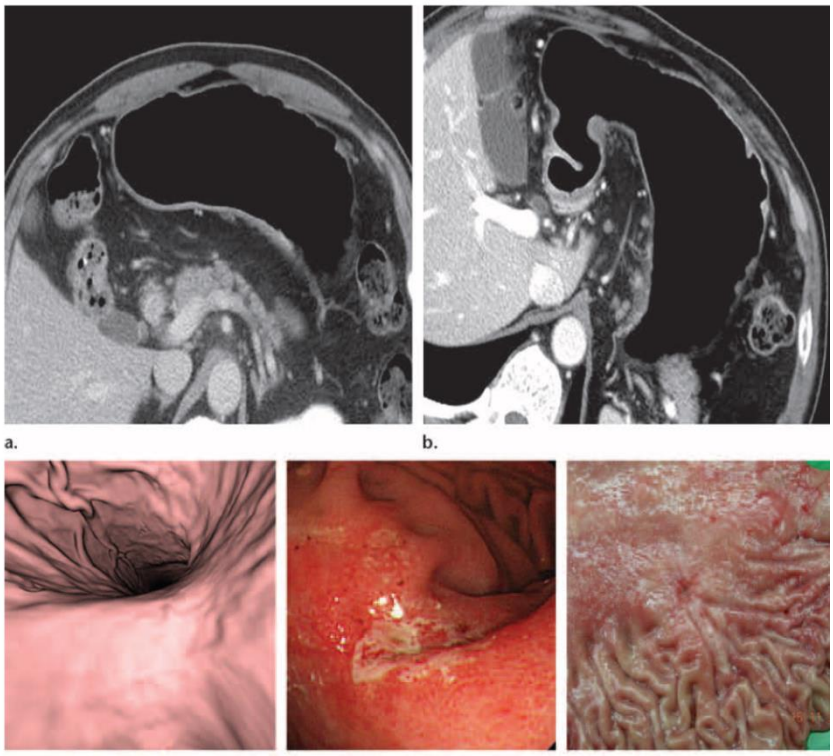
Type IIa + IIc: Superficial elevated and ulcerated lesion



Type IIb + IIc: Superficial flat and ulcerated lesion



Type IIc: Superficial depressed lesion



❖Advanced Gastric Cancer (AGC)

Morphological Features:

1) Polypoid lesion:

- Mass projecting in gastric lumen producing irregular filling defect

2) Malignant Gastric Ulcer:

- Location: Greater curve and gastric antrum
- Not extend beyond gastric wall
- Project into gastric lumen
- Large ulcer: width > depth
- Shape: Irregular & nodular
- Carman's meniscus sign: Ulcer is surrounded by lucent raised everted edges of the tumor. Its concavity towards gastric wall and its convexity towards gastric lumen.
- Mucosal folds: Irregular – Nodular – Clubbing – Amputated – Fused

3) Linitis Plastica:

- Diffuse submucosal infiltration and muscle invasion:
- Thickened rigid stomach
- Shrunken lumen
- Poor dispensability
- Loss of peristalsis

4) Annular Scirrhous Carcinoma:

- At gastric body => Hour glass stomach
- At pyloric antrum => Apple core appearance

CT Imaging Findings:

- A polypoid mass with or without ulceration
- Focal wall thickening with mucosal irregularity or focal infiltration of wall
- Ulceration: Gas-filled ulcer crater within mass
- Infiltrating carcinoma: Wall thickening + loss of normal rugal fold pattern

Mass Effect:

- Fundal carcinoma => Pseudo-achalasia
- Antral carcinoma => Gastric outlet obstruction

Extra-Gastric Spread:

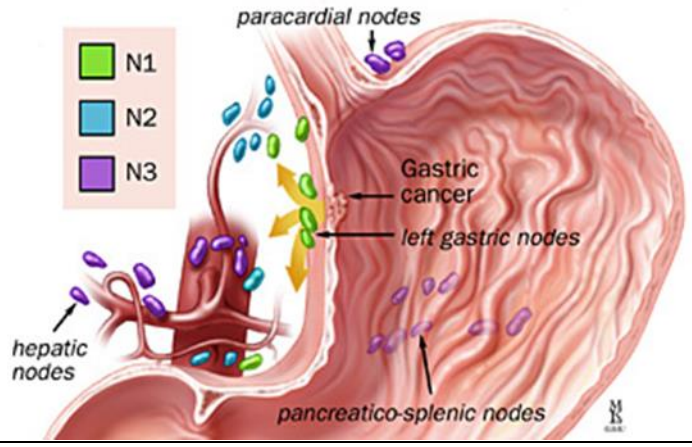
- Blurred serosa
- Strand like densities extending into perigastric fat
- Direct involvement of pancreas, diaphragm, liver and transverse colon.
- Vascular encasement.

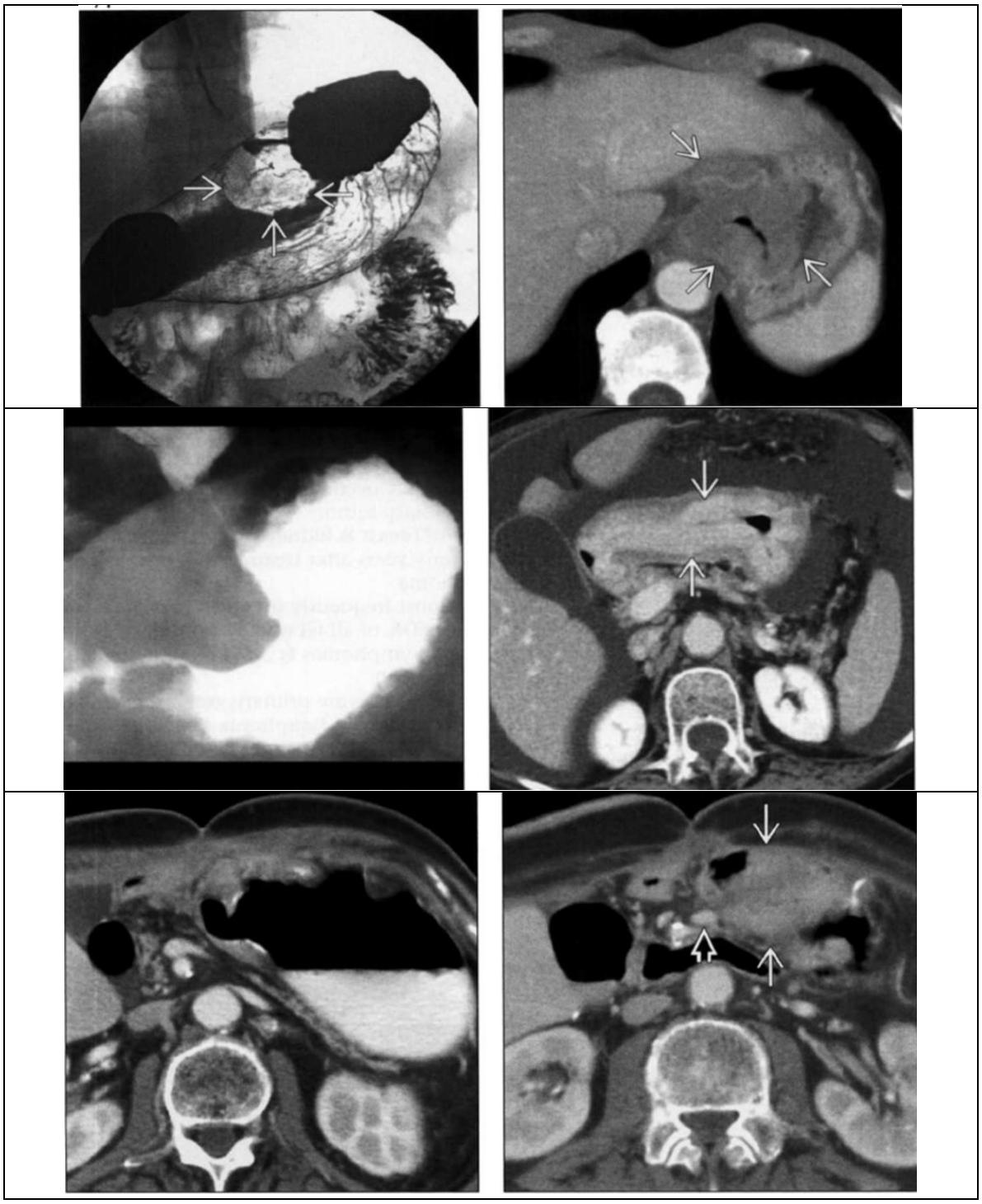
Peritoneal Spread:

- Ascites.
- Peritoneal nodules
- Omental cake
- Krukenberg tumor (Ovarian metastasis)

Table II. TNM classification (4th edition) for gastric cancer

Tis	*In situ*
T1	Limited to mucosa or submucosa
T2	Muscularis propria involved
T3	Serosal involvement
T4	Invasion outside the stomach
N0	No lymph node involvement
N1	Lymph node involvement 3 cm away from primary tumor
N2	Regional lymph node involvement (left gastric, common hepatic, celiac, splenic)
N3	Intra-abdominal distant lymph node involvement (duodenal, mesenteric, para-aortic, retropancreatic)
M0	No distant metastasis.
M1	Distant metastasis
Stage II	T1N1M0; T2N0M0
Stage II	T1N2M0; T2N1M0; T3N0M0
Stage III	T2N2M0; T3N1-2M0; T4N0-1M0
Stage IV	T4N2M0; T1-4N3





B) Mural = Subepithelial = Submucosal Tumors & Polyps

- **GIST (most common)**
- **Neuroendocrine tumors:**
  - **Typical carcinoid**
  - **Atypical carcinoid**
  - **Neuroendocrine Carcinoma**
- **Neurogenic tumors:**
  - **Schwannoma**
  - **Neurofibroma**
  - **Malignant Nerve sheath tumor**
- **Smooth muscle tumors:**
  - **Rhabdomyoma/ leiomyoma**
  - **Rhabdomyosarcoma/ leiomyosarcoma**
- **Vascular tumors:**
  - **Glomus**
  - **Hemangioma**
  - **Angiosarcoma**
  - **Kaposi sarcoma**
- **Lipoma**
- **Lymphoma**
- **Metastasis**
- **Heterotopic Tissue**
- **Polyps**

1) GIST

- GISTs => 90% (most common) of mesenchymal neoplasms of the GIT.
- GIST defines a unique group of mesenchymal neoplasms that are distinct from:
    - Smooth muscle (leiomyomas, and leiomyosarcomas)
    - Neural tumors (schwannoma, neurofibroma, carcinoid tumors).
- Age > 50 y

Location:

- GISTs arise anywhere in the GIT.
- From the esophagus to anus.
- Stomach: most common location
- Followed by jejunum and ileum.
- may also occur primarily in omentum, mesentery, and retroperitoneum.

- Esophagus => only site where leiomyomas predominate
    - 75% of esophageal mesenchymal tumors are leiomyomas
    - 25% are GISTs
    - Leiomyosarcomas are rare
- Stomach, small intestine, colon, and anorectum:
    - GISTs account for almost all mesenchymal tumors
    - Leiomyomas and leiomyosarcomas are very rare

Pathology and Immunophenotyping:

- Immunoreactivity for c-KIT (CD117).

- Patients with neurofibromatosis type 1 (NF1) have an increased prevalence of GISTs. (Patients with NF1 have multiple small intestinal GISTs)
- GISTs are likely a feature of the **Carney triad:**

(epithelioid leiomyosarcoma + paraganglioma + pulmonary chondroma)

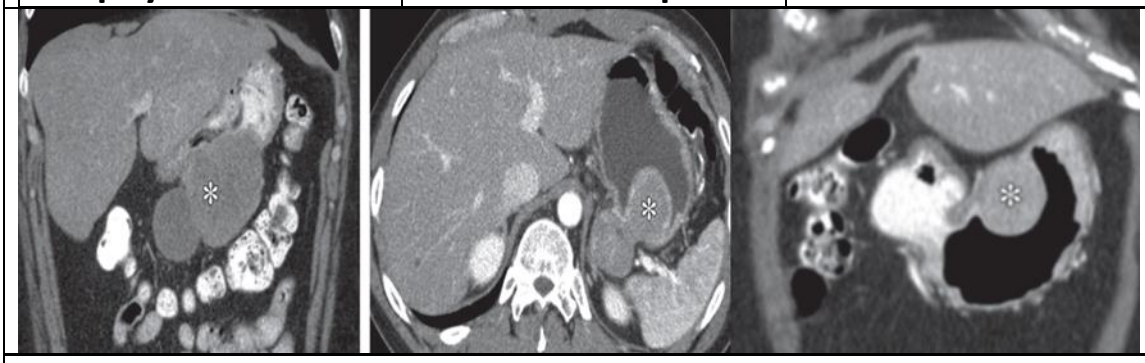
Clinical Presentation:

- Gastrointestinal bleeding from mucosal ulceration.
    - Hematemesis, melena, hematochezia, anemia .
- Nausea, vomiting, abdominal pain, weight loss, abdominal distention, and intestinal obstruction

Growth patterns of intramural masses:

- **Exophytic**
- **Dumbbell shaped**
- **Endoluminal (less common):**
    - Smooth overlying mucosa
    - Obtuse margins with the adjacent wall.
    - Central umbilication = focal ulceration= Bull's eye sign

Exophytic	Dumbbell shaped	Endoluminal



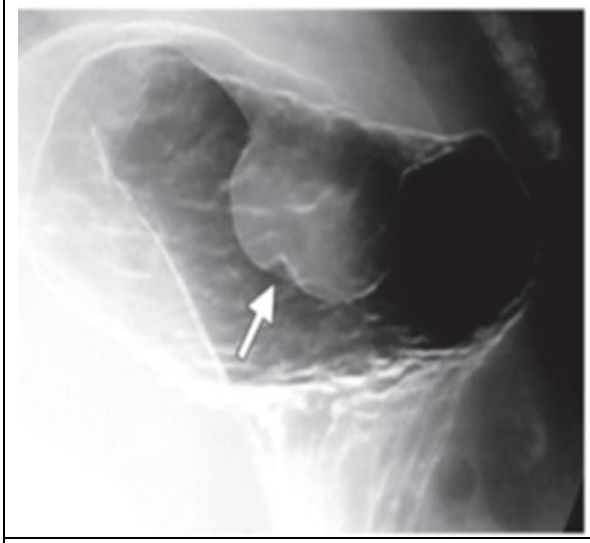
Imaging Findings:

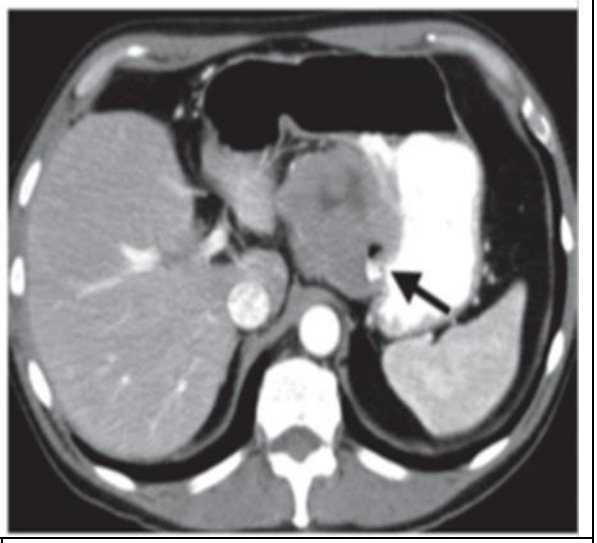
- Submucosal mass = Intact overlying mucosa ± Ulcer
- Heterogeneous = areas of hemorrhage + necrosis + cystic degeneration + Calcification.
- Adjacent organ invasion.
- Metastatic to liver and peritoneum (50%)
- Metastatic LNs are uncommon

Barium Study :

- Smoothly circumscribed mass
- Mural-based lesion
- Obtuse angles with the wall.

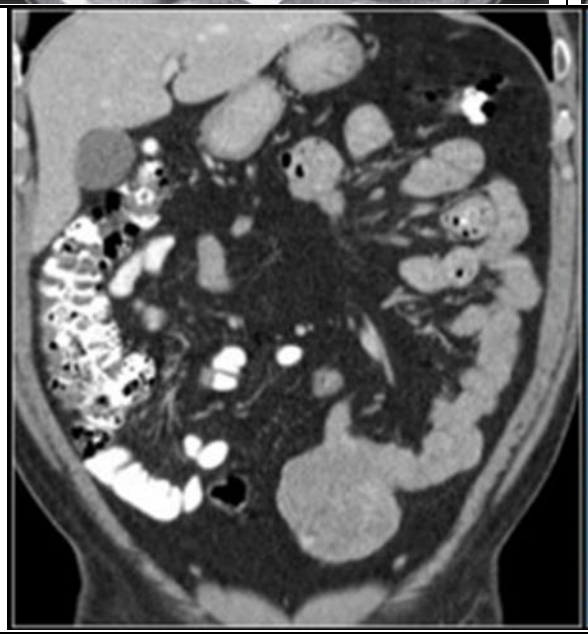
Submucosal mass + Intact overlying mucosa + Central Ulcer

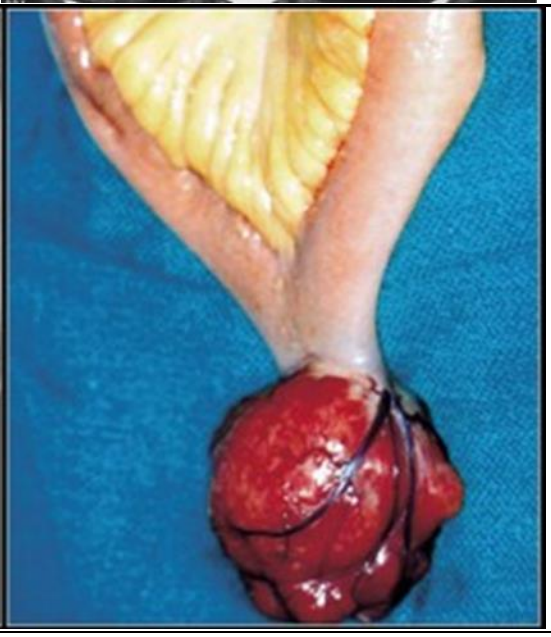




Heterogeneous = necrosis + hemorrhage

Calcifications





2) Neuroendocrine Tumors (NETs)

- NETs retain specific cell-membrane receptors, such as somatostatin receptors (SSTRs) that provide a pathway to localize and treat MNETs.
- GIT carcinoid tumors accounts for 85% of all carcinoid tumors
- GIT Carcinoid tumors accounts for 2% of all GIT tumors.

Syndromes may be associated with:

- Multiple endocrine neoplasia (MEN) type 1
- Zollinger Ellison syndrome
- Neurofibromatosis type I

Location:

- **Gastrointestinal tract carcinoid (85%)**
  - Appendiceal carcinoid - 50% of all carcinoid tumours
  - Small bowel carcinoid - terminal ileum accounts for ~ 90% of all small bowel carcinoid tumours
  - Gastric carcinoid
- **Brochopulmonary carcinoid:**
  - Bronchial carcinoid - accounts for 1-2% of lung tumours
  - Peripheral pulmonary carcinoid tumours
- Primary hepatic carcinoid
- Ovarian carcinoid (0.5% of carcinoid tumours)
- Thymic carcinoid

Diagnosis:

- CT or MRI Imaging
- Functional Imaging:
  - Indium-111 Octreotide scintigraphy : The most commonly used functional imaging study with detection rate of up to 90% for primary tumors or metastases
  - MIBG scintigraphy: lower sensitivity than does 111In octreotide scintigraphy
  - FDG PET
- Serological markers
  - 5HIAA - (5-hydroxyindoleaceticacid)
  - Chromogranin A
- Biopsy

Clinical Presentation:

- **Locally:**
  - Small bowel obstruction (due to desmoplastic reaction)
  - Bowel Ischemia (due to vascular encasement)
- **Metastatic:**
  - Liver and nodal metastasis
- **Carcinoid Syndrome 10%**

Mesenteric Disease:

- 40%–80% of midgut carcinoid tumors spread to the small-bowel mesentery
- either by direct extension or via local lymph nodes metastasis
- Speculated ill-defined enhancing soft-tissue mass
- Calcification 70% of cases
- Desmoplastic reaction
- Vascular encasement
- Small bowel ischemia = Dilated lumen + thickened wall
- Small bowel obstruction

Carcinoid Metastasis:

- Carcinoid tumor < 1 cm
  - Nodal and liver metastases incidence is 20-30%
- Carcinoid tumor 1-2cm
  - Nodal metastasis incidence = 60-80%
  - Liver metastases incidence = 20%
- Carcinoid tumor > 2cm
  - Nodal metastases incidence = 80%
  - Liver metastases incidence = 40-50%.

Carcinoid Syndrome 10%

- a spectrum of symptoms which includes flushing, diarrhea, bronchospasm, pain and right heart failure
- The symptoms result from systemic circulation of secretory substances: serotonin, histamine etc.
- The presence of the carcinoid syndrome often indicates hepatic metastatic disease
- usually from a primary bowel carcinoid tumour

Carcinoid Heart Disease (Hedinger syndrome)

- is seen in up to 50% of patients with carcinoid syndrome .
- It is characterized by plaque-like fibrosis that affects the right side of the heart, including the tricuspid valve, pulmonary valve, cardiac chambers, vena cavae, and coronary sinus
- The fibrosis is caused by serotonin and other fibrogenic factors that are released by the NET.

❖Grading & Classification of GIT NETs

Grade	Differentiation	Traditional Classification	ENETS and WHO 2010 Classification
Low grade (<2 mitoses/10 HPF, <3% Ki-67 index)	Well differentiated	Carcinoid tumor	Neuroendocrine tumor, grade 1 (G1)
Intermediate grade (2–20 mitoses/10 HPF, 3%–20% Ki-67 index)	Well differentiated	Carcinoid tumor	Neuroendocrine tumor, grade 2 (G2)
High grade (>20 mitoses/10 HPF, >20% Ki-67 index)	Poorly differentiated	Small cell carcinoma	Neuroendocrine carcinoma, grade 3 (G3), small cell carcinoma
		Large cell neuroendocrine carcinoma	Neuroendocrine carcinoma, grade 3 (G3), large cell carcinoma

❖WHO Classification:

- Well-differentiated tumors = Typical Carcinoid tumors = Low-grade
- Well-differentiated tumors = Atypical carcinoid tumors) = Intermediate grade = more aggressive + metastases.
- Poorly differentiated tumors = Small cell carcinoma + Large cell carcinoma = high-grade malignancies with a poor prognosis

❖GIT NETs:

a) **Appendiceal Carcinoid**
b) **Foregut/Gastric/Duodenal Carcinoid**
c) **Midgut/Small Bowel Carcinoid**
d) **Hindgut/Colonic/Rectal Carcinoid**

Imaging Findings:

- Primary lesion appears as an arterially enhancing submucosal intraluminal mass.
- Mesenteric LNs/Mass: Calcification, desmoplasia and vascular encasement.
- Liver, peritoneal, lung, and bone metastases can also be visualized

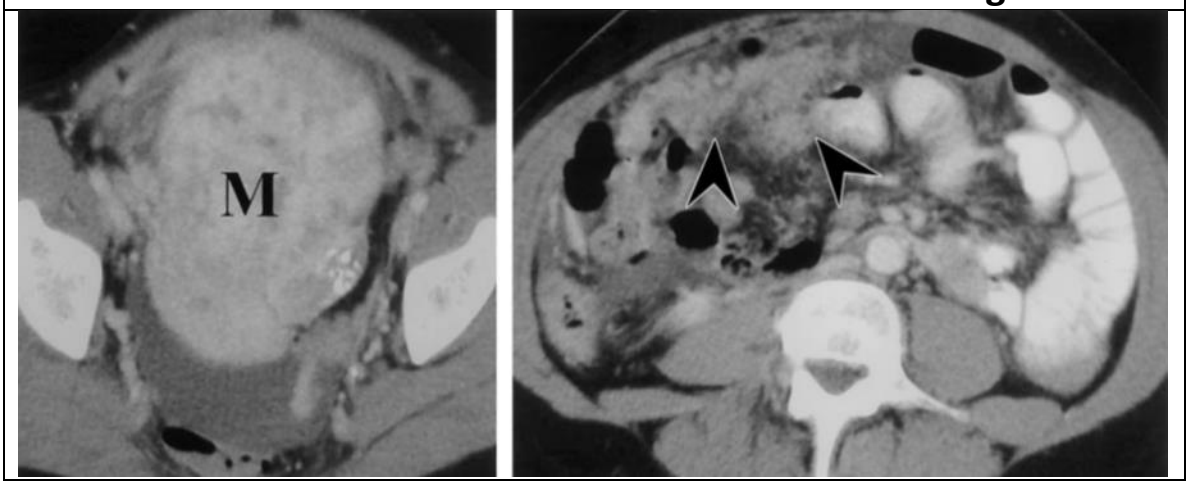
a) Appendiceal Carcinoid Tumors

- most common site for GIT carcinoid tumors
- most common type of appendiceal tumors
- Appendiceal tumors commonly present as acute appendicitis in young adults.
- Location: 70% are found in the distal third of the appendix (away from the base)
- Size: 95% are small < 2 cm in size
- 5-year survival rate > 90%

➢ Diffuse Infiltrative Pattern

Mesenteric soft tissue mass + Eccenteric calcification	Diffuse mural thickening of the appendix

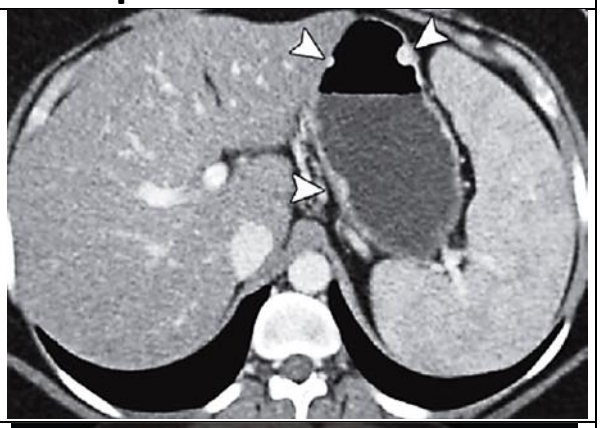
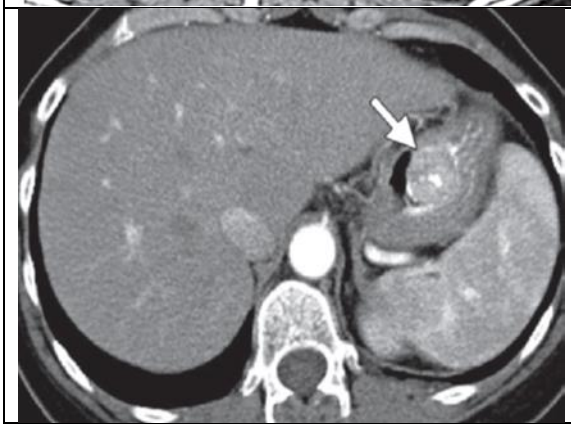
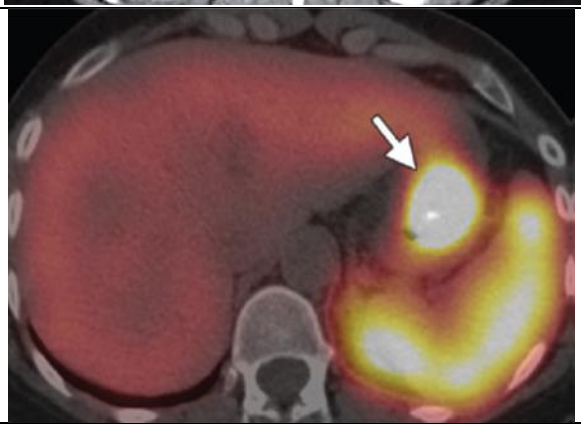
➢ Metastatic Goblet Cell Carcinoid + Omental Caking



b) Gastric NET

Type I: 70%–80%

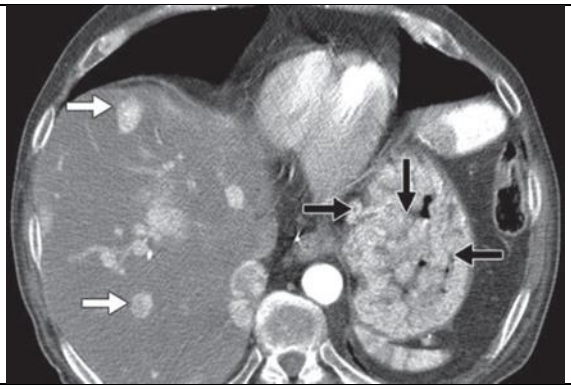
- Middle aged women
- is associated with achlorhydric atrophic gastritis
- Gastric fundus or body
- Detected coincidentally at endoscopy performed because of dyspepsia.
- Solitary or multiple
- Small (1 cm) submucosal enhancing nodules.

Solitary	Multiple
	
	

Type II: 5%–10%

- Almost exclusively in MEN 1 and Zollinger-Ellison syndrome with a Gastrinoma and hypergastrinemia.

- Multicentric and usually are small
- Gastric wall thickening 2ry to hypergastrinemia.
- Metastases to regional lymph nodes and the liver occur in 10%–30%

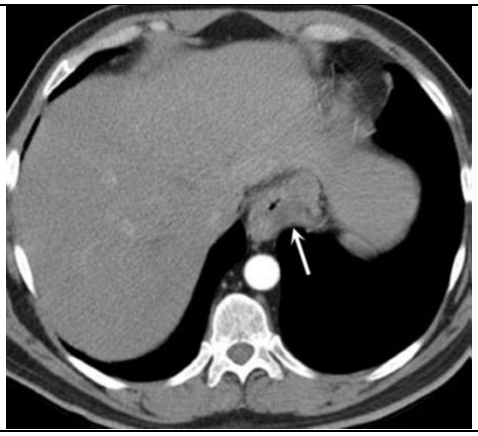


Type III: 15%–25%

- Sporadic
- in the absence of a predisposing gastric pathologic condition
- Solitary
- Large > 2 cm in diameter,
- behave more aggressively than do other subtypes
- metastases have developed at the time of diagnosis
- prognosis is poor,
- 5-year survival rate of 20%

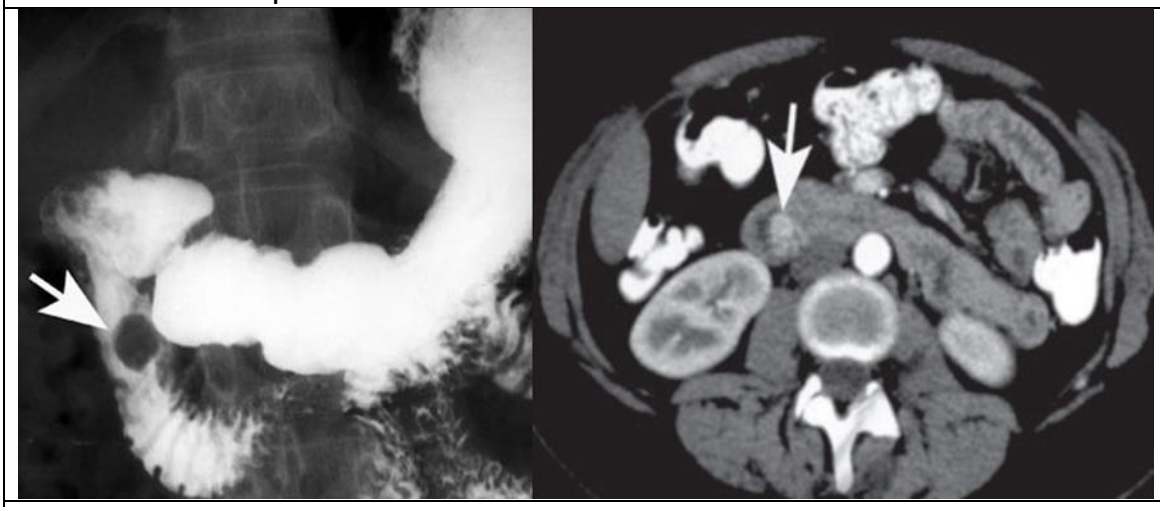
c) Esophageal Carcinoid Tumor

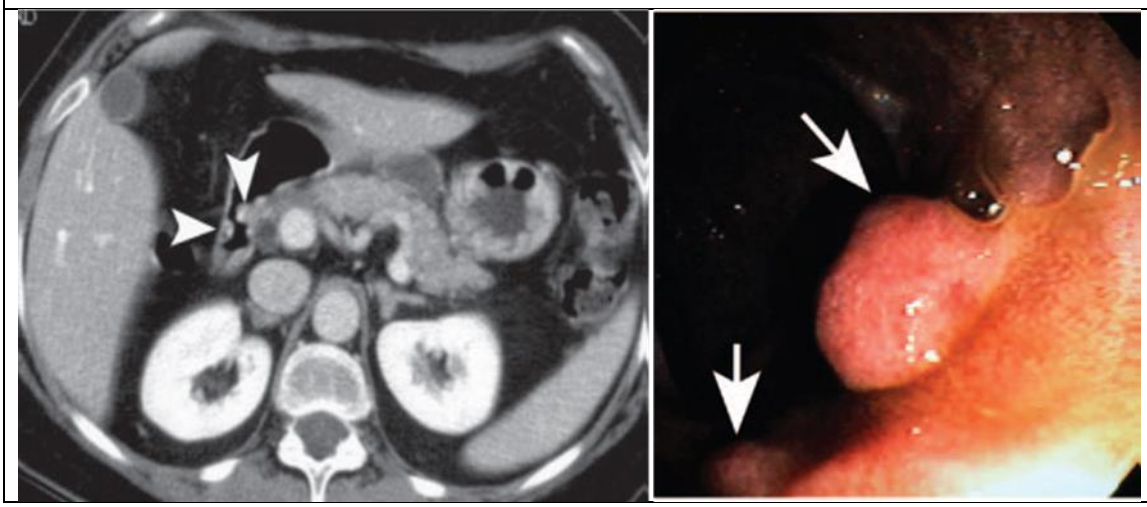
- extremely rare,
- present with symptoms of dysphagia.
- mimic those of esophageal carcinomas



d) Duodenal Carcinoid Tumor

A well-defined submucosal polypoidal mural or intraluminal enhancing lesion in Second portion of the duodenum



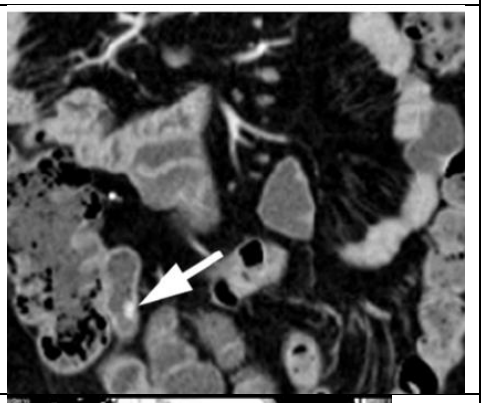


e) Midgut NETs

- 2nd most-common small bowel malignancy after adenocarcinoma
- Most common location is the distal ileum.

1ry lesion:

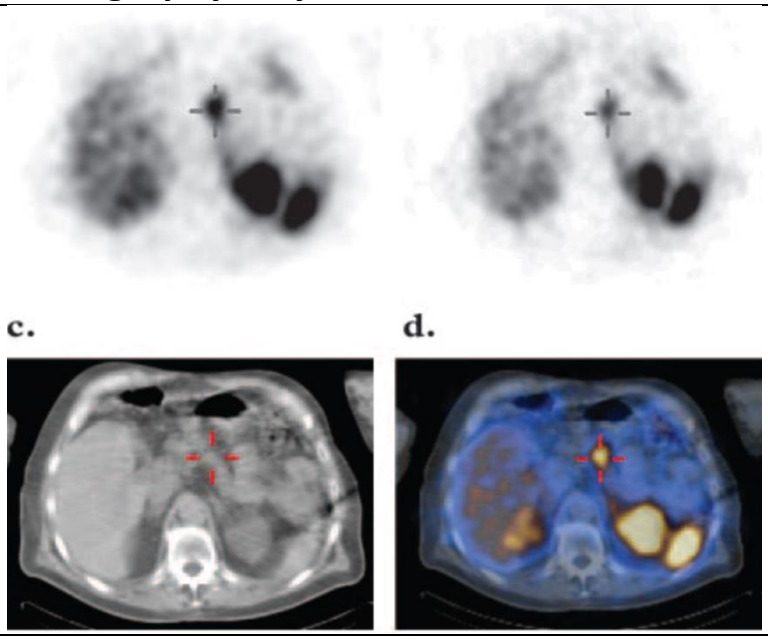
- Terminal ileum
- Sumucosal
- Intraluminal
- Small < 2cm
- Well defined
- Polypoidal
- Intense arterial enhancement



Mesenteric Nodal Mass

- Speculated mesenteric mass
- Calcification
- Desmoplastic reaction
- Vascular encasement
- Bowel ischemia =Dilated lumen + thickened wall

Octreotide Scintigraphy + hybrid SPECT/CT



3) Neurogenic Tumors

a) Nerve Sheath Tumors

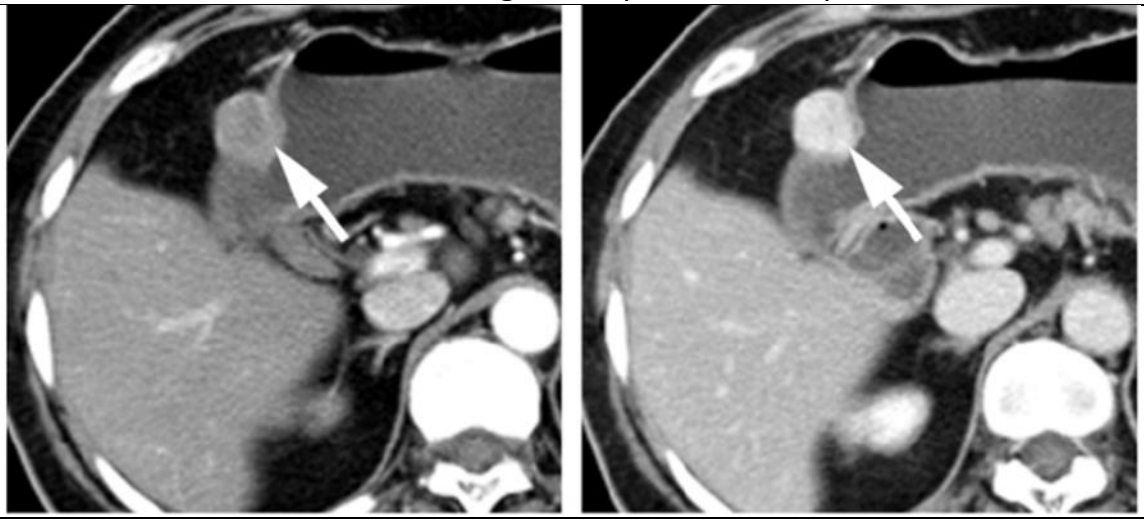
- Rare mesenchymal tumors arising from the Schwann cells of the neural plexus within the GI wall.
- Gastric schwannomas account for only 0.2% of all gastric tumors
- Occur most frequently in the 3rd to 5th decades of life.
- These tumors are usually discovered incidentally during endoscopic evaluation, although larger tumors may occasionally manifest as upper GI bleeding, abdominal pain, or discomfort.
- Malignant transformation is extremely rare.

Locations:

- The most common site is the stomach (60%–70% of cases)
- Followed by the colon and rectum.

Gastric Schwannoma:

- Well defined homogeneous submucosal lesion.
- Large tumors may undergo cystic degeneration.
- Smooth intact overlying mucosa
- Homogenous = No Hge or necrosis
- No Calcification
- No or minimal enhancement during the arterial phase
- Moderate enhancement during the hepatic venous phase.



b) Paraganglioma

- are extremely rare neoplasms that may be identified anywhere within the GI tract

4) GIT Lymphoma

- 1ry >> 2ry Lymphoma
- Most common site of extranodal lymphoma
- NHL >> HL
- Subtypes: B-cell > MALT > T-cell > Burkitt

Criteria of Diagnosis of 1ry Lymphoma: ⑤

1) NO palpable / superficial LNs
2) NO Mediastinal LNs => Normal CXR
3) NO Liver or spleen
4) NO BM => Normal blood smear /BM aspirate
5) Confined for GIT + Regional LNs

Staging: ⑤

I = Tumor confined to GIT
II 1= Tumor + Regional LNs
II 2= Tumor + Distant / Retroperitoneal LNs
III = Tumor + Invasion of surrounding organs
IV = Disseminated extra-nodal

Risk factors:

- H-pylori - AIDS - Immunosuppression - Celiac disease – IBD .

Location: Any part of GIT

- Common: Stomach > SI (Distal ileum) > LI
- Rare: Esophagus - Rectum

Patterns of growth:

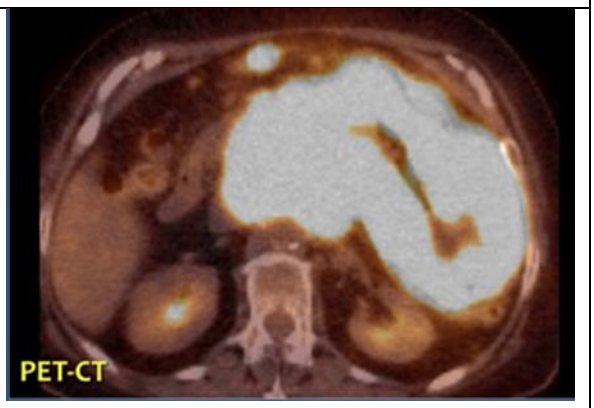
- Polypoidal mass - Ulcerative - Infiltrative

Radiological features:

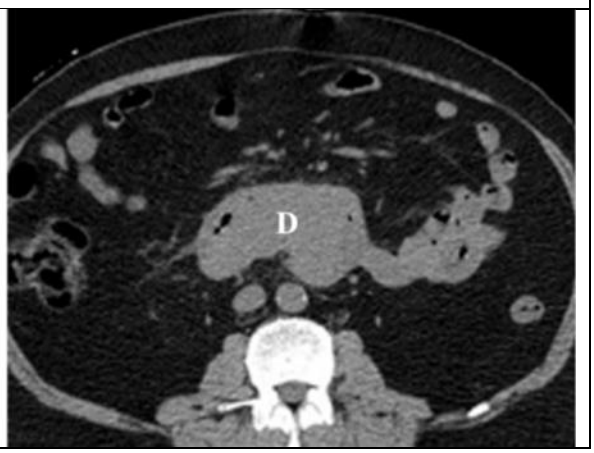
- Circumferential wall infiltration
- Long segment (Transpyloric spread & Trans ileal spread)
- Multiple sites.
- Preservation of the surrounding fat planes
- No invasion of the surrounding structures.
- No obstruction of lumen
- Aneurysmal dilatation of lumen: secondary to destruction of the autonomic nerve plexus by tumor infiltration.
- Associated bulky lymphadenopathy.
- Associated splenomegaly

Gastric Lymphoma

Small bowel lymphoma
Aneurysmal dilatation of lumen + No obstruction
Terminal Ileum is most common location

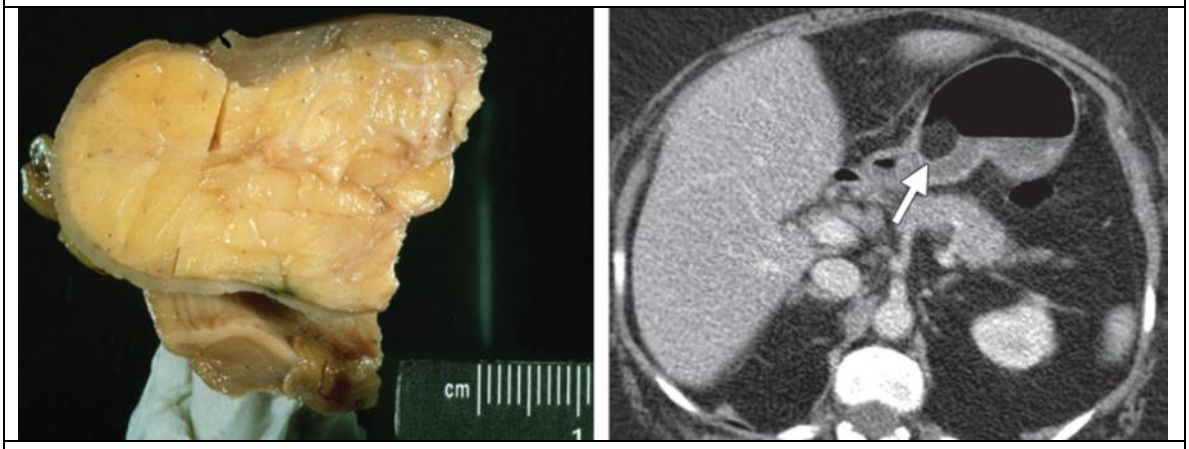


Duodenal Lymphoma



5) Lipoma

- Lipomas are composed of mature fat cells surrounded by a fibrous capsule
- Asymptomatic.
- Most common location = Gastric antrum
- Submucosal endoluminal mass
- Fat attenuation = -70 to -120



6) Leiomyoma

- Rare.
- Negative for c-KIT
- Positive for desmin and smooth muscle actin
- The distinction between GISTs and leiomyomas is clinically important, because leiomyomas are benign and GISTs are associated with a variable risk of progression and metastasis.
- In stomach, small bowel, and colon: GIST >>>>> leiomyoma.
- In esophagus is the only site: Leiomyoma >>>>> GIST.

7) Metastases

The mechanism of GI metastases includes :

a. Direct extension from a contiguous or noncontiguous primary malignant tumor.
b. Peritoneal carcinomatosis with serosal implants
c. Hematogenous metastases with intramural subepithelial masses.

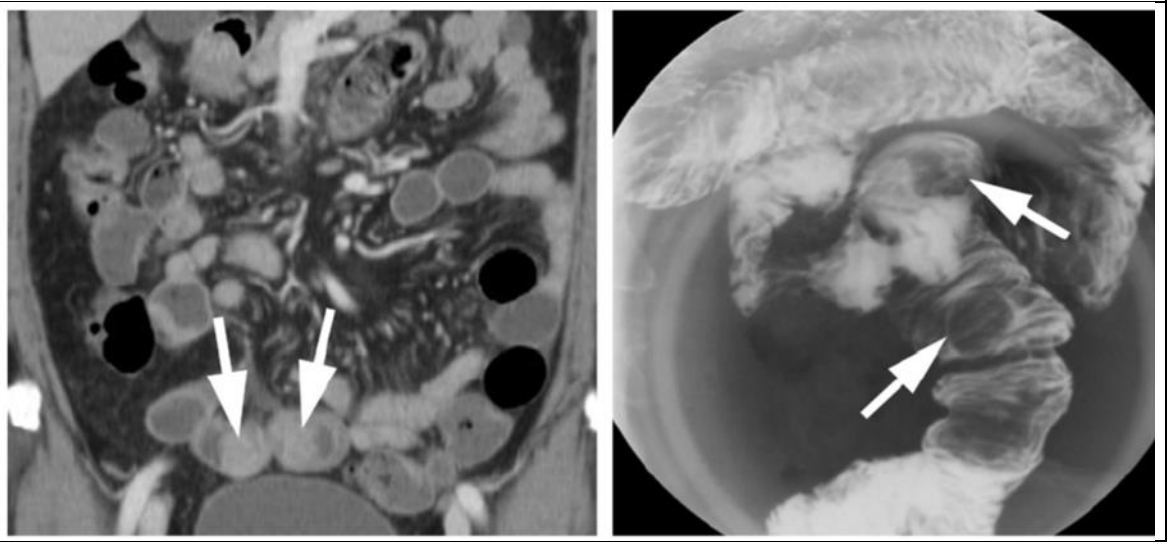
Imaging findings:

- GI metastases closely resemble the primary tumors; therefore, the radiologic appearance of GI metastases depends mainly on the histologic characteristics of the primary or secondary lesions, such as the degree of vascularity relative to the growth rate.
- Submucosal polypoidal lesion
- "Target" or Bull's-eye lesion

Hypervascular GI metastases:-

- Malignant melanoma
- Breast cancer.
- Renal cell carcinoma.
- Choriocarcinoma.
- Neuroendocrine carcinoma.
- Mesenchymal sarcoma

Small bowel metastasis for malignant melanoma



8) Vascular Tumors

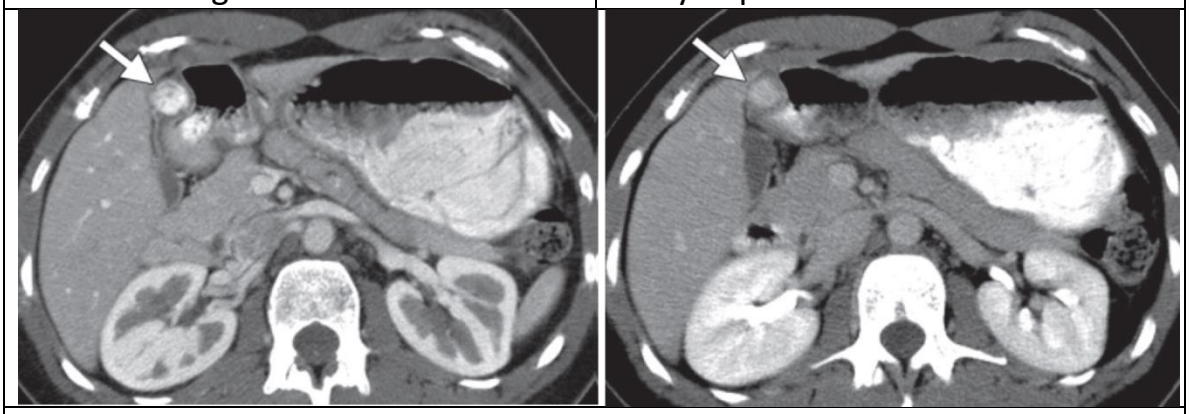
a) Glomus Tumor

- Rare, benign, vascular tumors that originate from glomus bodies.
- The glomus body is a unique arteriovenous shunt, which is believed to regulate temperature.

Location:

- Glomus tumors are usually found in extremities , particularly beneath the fingernails, they have been described in virtually every organ system
- In the GI tract, glomus tumors occur almost exclusively in the stomach. particularly the antrum.
- Gastric glomus tumors are rare
- 2% of all benign gastric tumors.

Solitary submucosal hypervascular lesion in the gastric antrum	Persistent enhancement in the delayed phase



b) Hemangioma

- GI hemangiomas are unusual vascular tumors that may occur anywhere in the GI tract and may be single or multiple.
- They are commonly associated with a cutaneous hemangioma.
- Multiple lesions are associated with syndromes such as:
  - **Maffucci syndrome**
  - **Klippel- Trénaunay syndrome**
  - **Blue rubber-bleb nevus syndrome.**

Imaging findings:

- An intramural subepithelial mass with an intraluminal growth pattern
- Transmural circumferential bowel wall thickening extending into surrounding tissue

- Dynamic CECT demonstrate slow diffuse enhancement, which is similar to that seen in hemangiomas elsewhere, and vascular engorgement within the adjacent mesentery around mass lesions, which reflects increased lesion vascularity.
- CT may reveal phleboliths caused by calcified thrombi within the tumor vascular channels, a finding that is virtually pathognomonic for a GI hemangioma

c) Angiosarcoma

- are rare, aggressive, malignant vascular tumors
- the precise cause of these tumors remains unclear, factors that have been implicated in their pathogenesis include
    - trauma
    - exposure to vinyl chloride,
    - thorium dioxide (Thorotrast)
    - arsenic compounds;
    - Long-standing lymphedema;
    - Radiation therapy.
- The presenting symptoms are nonspecific and include
    - GI hemorrhage and anemia, perforation, pain

d) Kaposi Sarcoma

- Common in patients with (AIDS) but also occur in patients without AIDS.
- GI involvement occurs in 40%–50% of AIDS-related Kaposi sarcomas and is almost always associated with cutaneous disease.
- The diagnosis of GI Kaposi sarcomas is usually made by using endoscopy and biopsy.
- The typical endoscopic findings include an ulcerated subepithelial mass or masses with a reddish appearance

Imaging findings:

- one or more small (0.5–3 cm in diameter) polypoid subepithelial masses
- enhancement of the masses is greater than that of the adjacent mucosa secondary to the high tumor vascularity
- lung nodules, highly enhanced lymph nodes, or splenomegaly
- Central ulceration is also common, resulting in the appearance of “bull’s-eye” or “target” lesions in barium studies.

9) Ectopic Pancreatic Tissue = Heterotopic Pancreatic Tissue

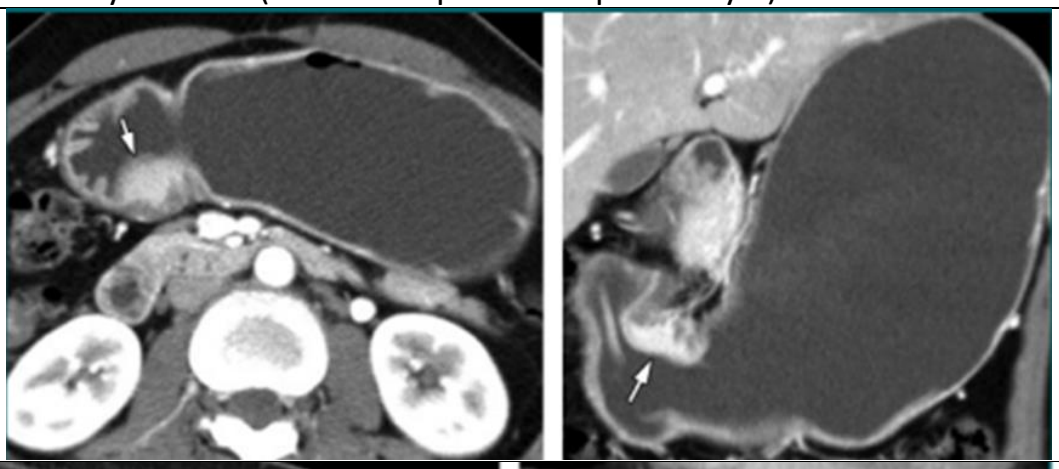
- Rests of pancreatic tissue lie outside and separate to pancreatic gland.
- Most patients are completely asymptomatic.

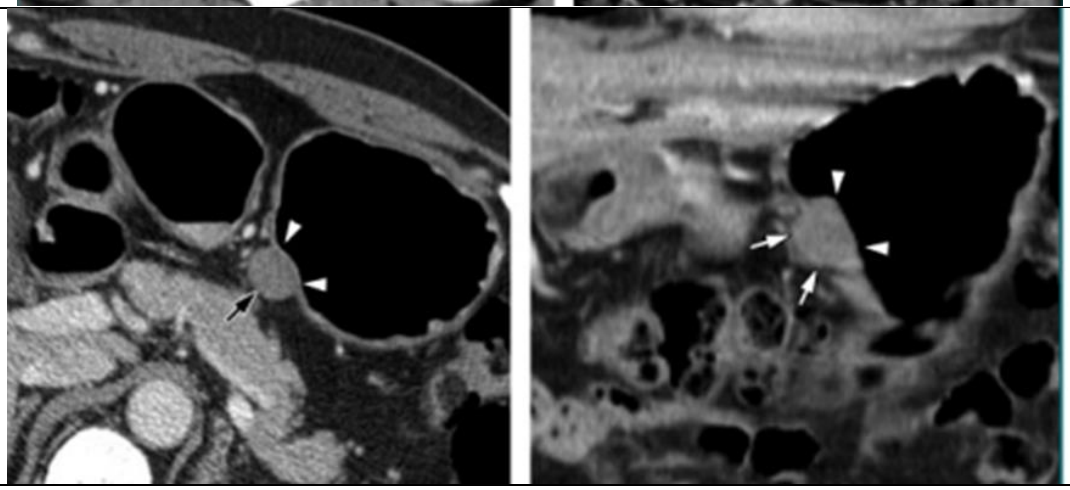
Recognized locations for ectopic pancreatic tissue include:

- Proximal duodenum
- Gastric antrum including within gastric duplication cysts
- Meckel's diverticulum
- Ileum

Imaging findings:

- Submucosal broad based polypoidal lesion
- +/- central umbilication = Bull's-eye lesions
- Homogeneously enhancing tissue (similar to normal pancreas)
- or cystic area (acinar component or pseudocyst).





C- Polyps

1) Adenomatous Polyp

- True neoplasm with very low malignant potential (<4%)
- Often single with lobulated or cauliflower-like surface
- Occurs in patients over 50 years old
- Risk of malignant change via adenoma-carcinoma sequence

Histological subtypes of adenomatous polyps:

- **Tubular adenoma:** 75% of neoplastic polyps
- **Villous adenoma:** 10% of neoplastic polyps
- **Tubulovillous adenoma:** 15% of all colonic polyps

Malignant potential:

- Lesions < 1 cm (5%), 1-2 cm (10%), > 2 cm (53%)

Location

- Rectosigmoid > cecum > ascending colon > stomach > duodenum

Imaging finding (barium study or CT colonography):

- Polypoid lesion with nodular or frond-like surface

Greater risk of carcinoma

- **Gastric Carcinoma**
  - 50% of lesions 2-4 cm
  - 80% of lesions > 4 cm in size
- **Duodenum Carcinoma**
  - 30-60% of villous tumors > 4 cm
- **Colon Carcinoma:**
  - Carcinoma in situ in 10%
  - invasive carcinoma in up to 45% of cases

2) Hyperplastic Polyp / Inflammatory polyp

- Proliferated, inflamed, edematous mucosa and inflammatory cells
- Associated with pernicious anemia
- Usually multiple, Smooth, sessile, pedunculated.
- Usually <1cm with no progression
- No malignant potential

3) Hamartomatous Polyp

- Rare
- Densely packed gastric glands
- Associated with Peutz-Jeghers syndrome
- Cluster of broad based polyps
- Usually <2cm in diameter

4) Peutz-Jeghers Syndrome

- is an inherited autosomal dominant condition characterized by:
    - Multiple hamartomatous GI polyps
    - Mucocutaneous pigmentation of lips, oral mucosa, palms & soles.

Distribution:

- Polyps can develop anywhere within the gastrointestinal tract.
- The most frequent locations, in order of prevalence:
    - Jejunum > ileum > Duodenum > Colon > Stomach.
    - Mouth and oesophagus are spared

Clinical Presentation:

- Intussusception => Intestinal Obstruction

Patients are at increased risk of:

- GIT adenocarcinoma: the polyps themselves are not premalignant
- Extra-intestinal malignancies:
    - Adenoma malignum (adenocarcinoma subtype of the cervix)
    - Breast – Pancreas – Lung – Uterus
    - Ovary: sex cord tumours
    - Testis: sertoli cell tumours

5) Cronkhite–Canada Syndrome

- is a type of non-hereditary hamartomatous polyposis syndrome characterized by rash, alopecia, and watery diarrhea.

Distribution:

- Predominant involvement of the stomach, large intestine
- To a lesser extent, small bowel

- It is not associated with a malignancy

6) Cowden Syndrome

- Multiple hamartoma syndrome, is characterized by multiple hamartomas throughout the body and increased risk of several cancers.

Increased risk of cancers such as:

- Breast cancer: develops in 30-50% of those with the syndrome
- Thyroid cancer: develops in 5% of those with the syndrome
- CNS: dysplastic cerebellar gangliocytoma, occurs when in association with

Lhermitte-Duclos disease (LDD)

7) Juvenile Polyposis Syndrome

- Juvenile polyposis syndrome is characterized by the presence of hundreds of hamartomatous polyps containing fluid/mucous

Clinical presentation

- Rectal bleeding, bowel obstruction and intussusception.

Associations Other congenital abnormalities:

- Intestinal malrotation - Meckel diverticulum - Hydrocephalus - Congenital heart disease - Mesenteric lymphangioma - Pulmonary arteriovenous malformation

Increased risk of cancers:

- These hamartomatous polyps may degenerate into adenomas and subsequently ~40% will develop colorectal carcinoma

8) Familial Adenomatous Polyposis Syndrome (FAPs)

- Characterized by presence of hundreds of adenomatous polyps in the colon.

Clinical presentation

- Rectal bleeding, diarrhea, abdominal pain, anemia, mucosal discharge

Increased risk of cancers:

- **Colorectal carcinoma:**
  - 7% of FAP carriers develop CRC by age 21
  - Almost every carrier develop CRC by 35-40 year

9) Gardner Syndrome

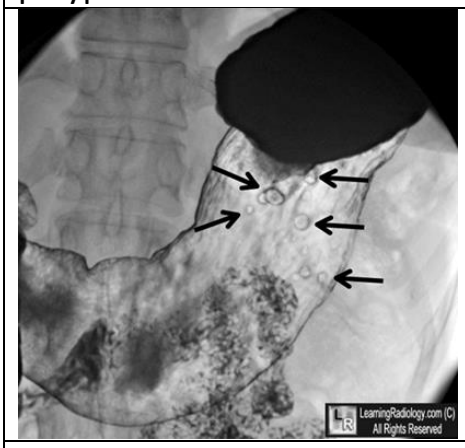
- An autosomal dominant disorder
- Association between:

✓ ***Colonic familial adenomatous polyposis***
✓ ***Multiple osteomas,*** especially of the mandible, skull and long bones
✓ ***Desmoid tumours*** of mesentery and anterior abdominal wall
✓ ***Dental abnormalities:*** supernumerary teeth
✓ Extra-colonic malignancy:
  ✓ Duodenal tumours / ampullary carcinoma – Pancreatic – Gastric – CNS – Hepatoblastoma – Papillary thyroid carcinoma

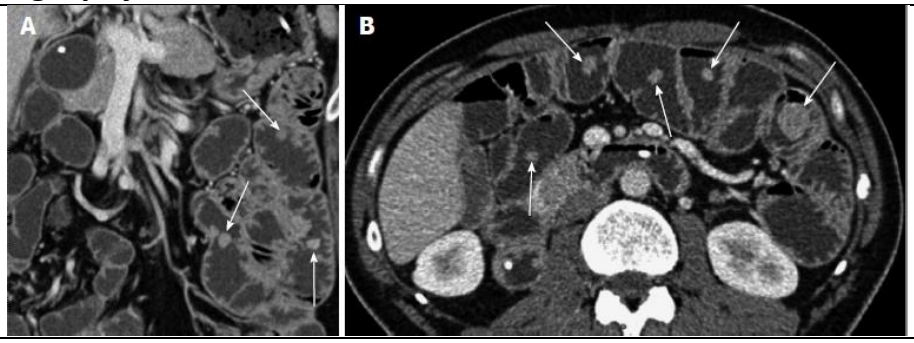
10) Turcot syndrome

- is the association of:
  ✓ ***Colonic familial adenomatous polyposis***
  ✓ ***Brain tumors.***

Barium Study:

Mexican hat sign:	***Bowler Hat Sign:***
Pedunculated polyp (en face) Pair of concentric rings Outer ring represents head of polyp Inner ring represents stalk of polyp	Sessile polyp in profile The bowler hat points towards the lumen which favors a polyp. Brim of hat represents base of polyp Dome of hat represents head of polyp
	

CT Enterography



Multidetector CT Virtual Endoscopy

Bariatric Surgery

- Bariatric surgery is increasingly performed to control morbid obesity secondary to failed medical approaches.
- Obesity is a serious, multifactorial, chronic illness affecting patients of all ages that continues to increase in prevalence at an alarming rate.
- The most practical means of classifying obesity is the body mass index (BMI).
- Obesity is defined as a BMI of 30 or greater.
- Morbid obesity is defined as a BMI of 35 or greater with serious comorbidity or as a BMI of 40 regardless of the presence or absence of comorbidities.

Role of Imaging:

- **Normal postsurgical anatomy**
- **Common postsurgical complications**

Bariatric Surgical Techniques => ② Categories:

a) Restrictive procedures:
   - Gastric volume is reduced substantially to decrease caloric intake by promoting early satiety.

b) Malabsorptive procedures:
   - The gastrointestinal tract is surgically altered to induce malabsorption and hence decrease caloric intake.

c) Combined techniques

❖ Complications

Early Complications:

- Anastomotic leak: usually at the gastrojejunal anastomosis
- Acute ischaemia

Late Complications:

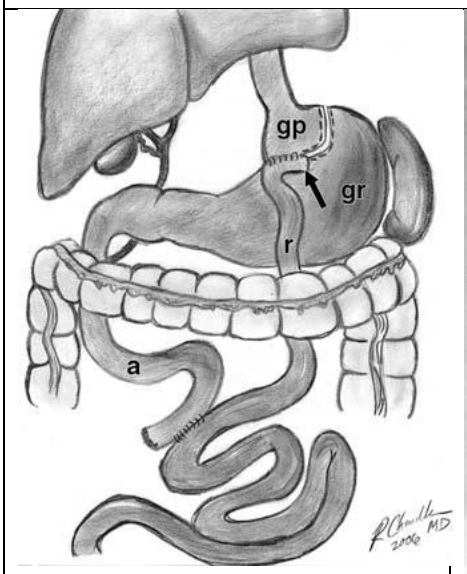
- Anastomotic narrowing/stenosis/stricture
  - most common cause of postoperative nausea and vomiting
- infection / Abscess
- Bezoar formation in the gastric pouch
- Ulceration
- Haemorrhage / haematoma
- Adhesions
- Small-bowel obstruction
- Internal hernia / Transmesenteric herniation
- Gastroesophageal reflux

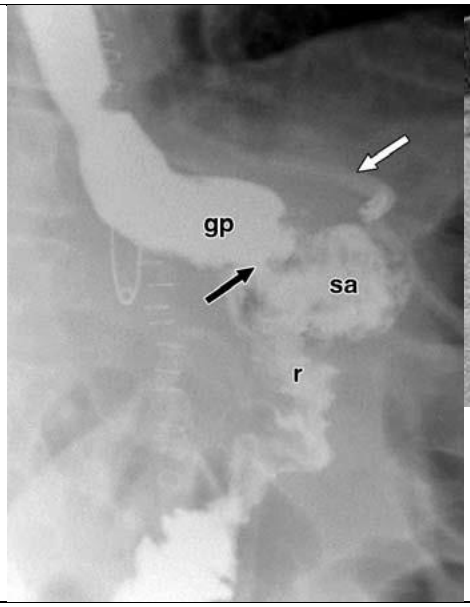
1) Roux-en-Y gastric bypass.

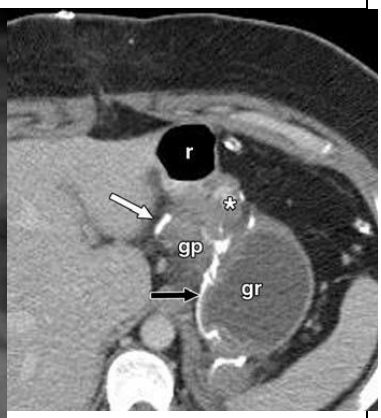
- Formation of a 15- to 30-mL gastric pouch that is surgically removed from the rest of the stomach (remnant stomach).
- The jejunum is divided approximately 30–40 cm distal from the ligament of Treitz, mobilized from the mesentery, and brought up to create a side-to-side gastrojejunostomy with the gastric pouch. This anastomosed jejunal loop is referred to as the Roux limb or efferent limb and is placed retrocolic through an opening created in the transverse mesocolon or antecolic in front of the transverse colon.
- A jejunojejunostomy is created approximately 100–150 cm distal from the gastrojejunostomy and all mesenteric defects are closed

- The Roux-en-Y gastric bypass is a mixed procedure, taking advantage of both restrictive and malabsorptive components to induce weight loss.

r=retrocolic Roux limb
gp= gastric pouch
gr = gastric remnant
a= afferent limb







<u>Initial imaging is performed on postoperative day 1 with a Gastrografin fluoroscopy study to assess for:</u>

- Leak proximally at the gastrojejunostomy and distally at the jejunojejunostomy.

- The retrograde flow of oral contrast material into the afferent limb and gastric remnant is common.
- Often gastric fluid or air can be seen in the remnant stomach as well.
- None of these findings involving the gastric remnant should be mistaken for abscess or gastrojejunal anastomotic leak

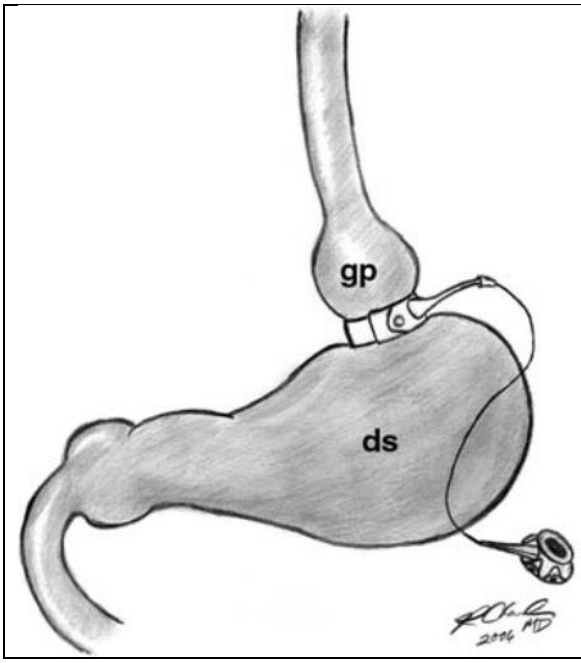
2) Laparoscopic Adjustable Gastric Banding

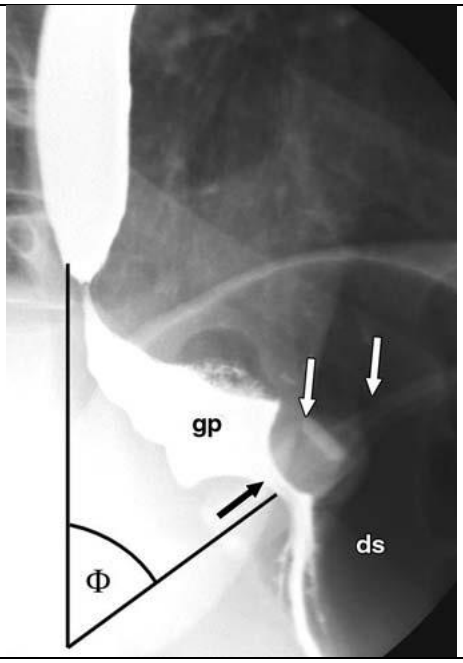
- This surgical technique involves placing an adjustable silicon band lined with an inflatable balloon around the superior stomach to partition a small gastric pouch and create an adjustable stoma into the remainder of the stomach.
- The anterior gastric wall is often sutured over the band to the gastric pouch to decrease the chances of band slippage.
- The balloon is then connected via tubing to a port placed subcutaneously in the abdomen
- Through aspiration or injection of saline into the port, the size of the band is decreased or increased, and hence the diameter of the gastric stoma adjusted

<u>On postoperative day 1, patients undergo fluoroscopic evaluation to assess:</u>

- Gastric pouch size for possible contrast extravasation from occult iatrogenic gastric injury
- Unhindered passage of orally administered contrast material into the remainder of the stomach via the surgically created stoma.
- The gastric pouch should be relatively symmetric in shape and measure approximately 3–4 cm in maximum dimension when distended with contrast material.
- The stoma should measure approximately 3–4 mm in diameter
- Contrast material should empty from the pouch 15–20 minutes after contrast administration

- Another factor assessed on every fluoroscopic examination is the phi angle.
- The phi angle is created by intersecting a line drawn parallel to the spinal column with a line drawn parallel to the plane of the gastric band, on an anteroposterior projection.
- Normally, this angle should range from 4° to 58° and lie approximately 4–5 cm below the left hemidiaphragm



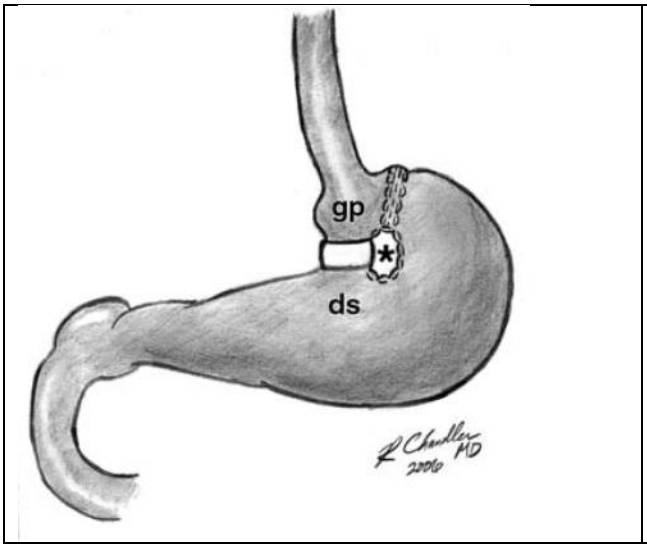


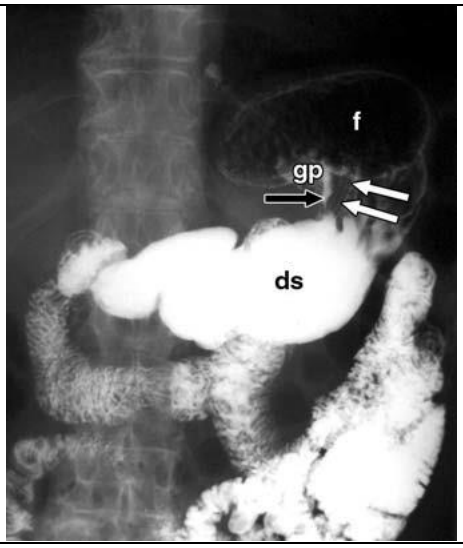
3) Vertical-Banded Gastroplasty

- Mason's technique for VBG involves creating a small gastric pouch, based on the lesser curvature of the stomach, by using a stapler to vertically partition the stomach.
- A polypropylene mesh band is wrapped around the stomach and placed through the window to create a small proximal gastric pouch and a small stoma into the remainder of the stomach

Initial postoperative imaging is performed with fluoroscopy to assess for :

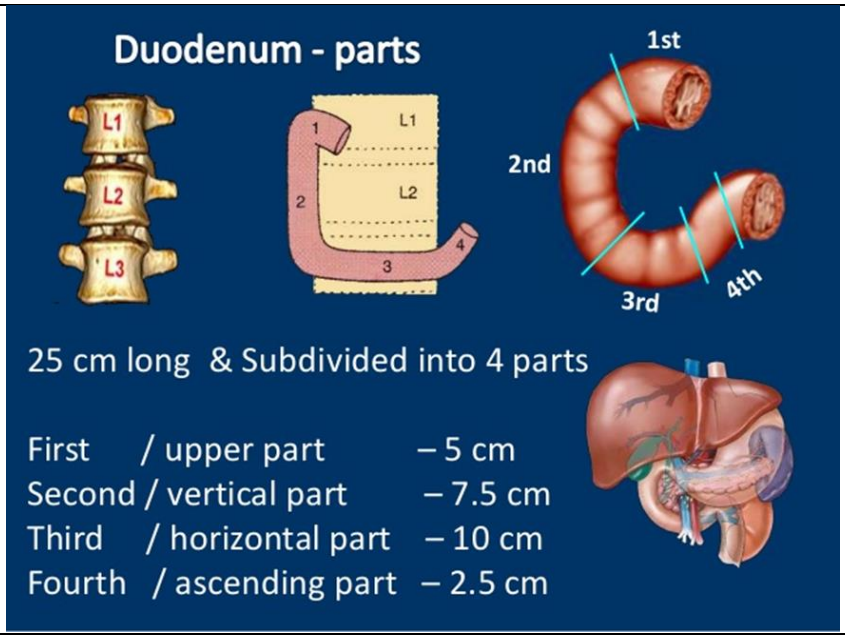
- Contrast extravasation
- Staple line competence
- Gastric pouch size for unhindered passage of orally administered contrast material through the surgically created stoma.

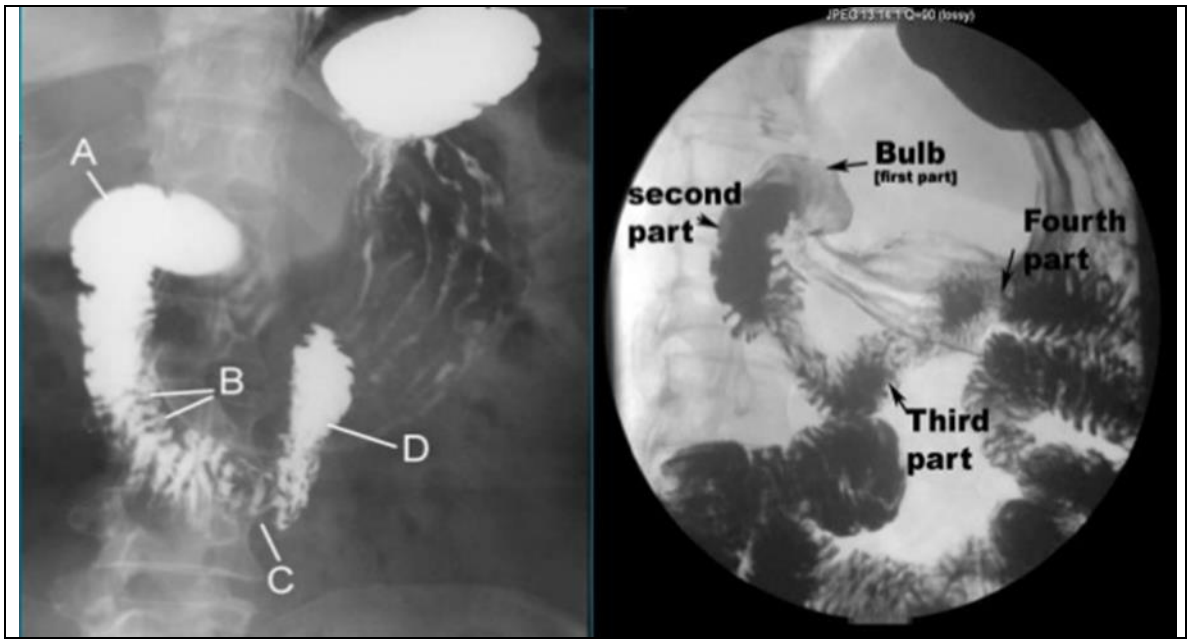




Duodenum

Duodenal Anatomy



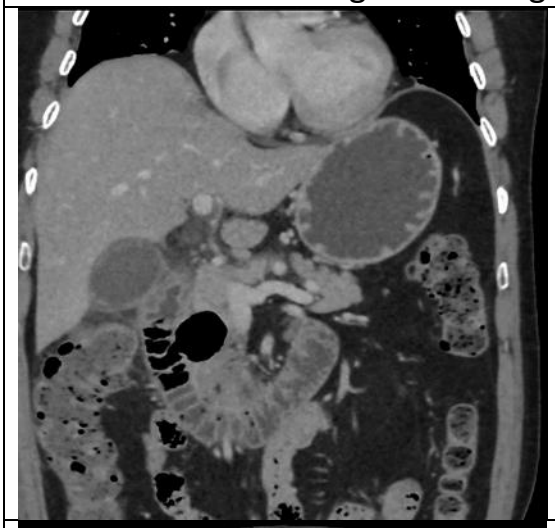
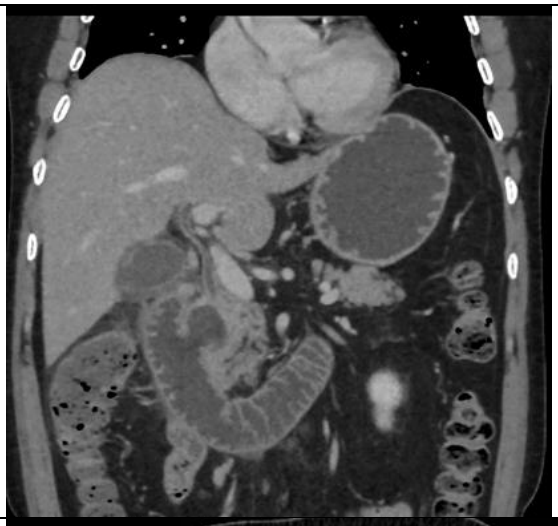
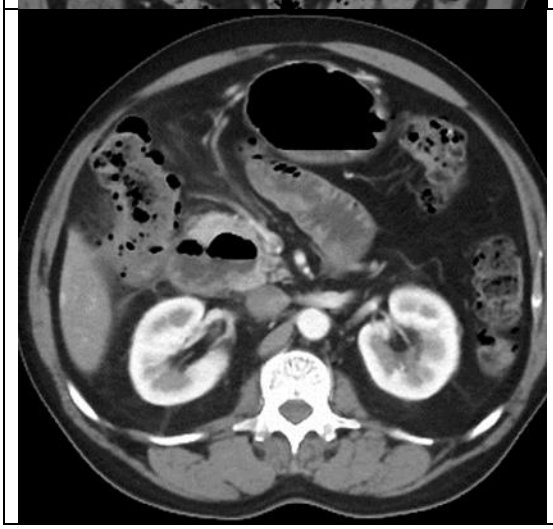


Duodenal Diverticulum

- is outpouchings from the duodenal wall

- Location: **<u>Periampullary Duodenal Diverticulum:</u>**
- located close to the 2nd duodenal segment

- Saccular outpouchings from the duodenum
- may contain gas, fluid, contrast or food debris
- It often contains a gas-fluid or gas-contrast level.

Duodenitis

A) Non-infective Inflammatory

- Secondary involvement from
  - Pancreatitis: considered most common
  - Cholecystitis
- Crohn disease: duodenal involvement in 0.5-4% of cases
- AIDS
- Post radiation therapy
- NSAIDs
- Alcohol
- Diverticulitis
- Gastric hypersecretion
  - Ectopic gastrinoma (Zollinger-Ellison syndrome)

B) Infective

- Helicobacter pylori: considered the most common infectious cause
- Giardiasis
- Tropical sprue

Imaging Findings:

- Thickening of mucosal folds
- Nodules or nodular folds
- Erosions.
- Deformity of the duodenal bulb also may be seen.

Duodenal Filling Defects

❖ **Multiple small rounded well defined submucosal nodules "cobblestone" or "Swiss cheese" appearance**

1) **Brunner Gland Hyperplasia**
2) **Heterotopic Gastric Mucosa**
3) **Heterotopic Pancreatic Tissue**
4) **Benign Lymphoid Hyperplasia**

❖ **Duodenal polyps (much less common than gastric)**

5) **Adenomatous polyps (most common)**

Single, lobulated or cauliflower-like surface
Classified as tubular, tubulovillous, or villous.

6) **Hyperplastic polyps**

Multiple, small, sessile polyps of uniform size

7) **Hamartomas polyps:**

Cluster of broad-based polyps
Can occur as part of Peutz-Jeghers syndrome

❖ **Duodenal Submucosal (Intramural) Tumors:**

8) **Duodenal GI stromal tumor (GIST)**

Soft tissue density mass that deforms lumen
Lesions ≥ 2 cm often have central necrosis

9) **Duodenal lipoma**

Characteristic fat density on CT
Other mesenchymal tumors (rare)

10) **Carcinoid tumor**

Single or multiple; may ulcerate → "target" lesions

Periampullary Tumors

(Discussed with Pancreas)

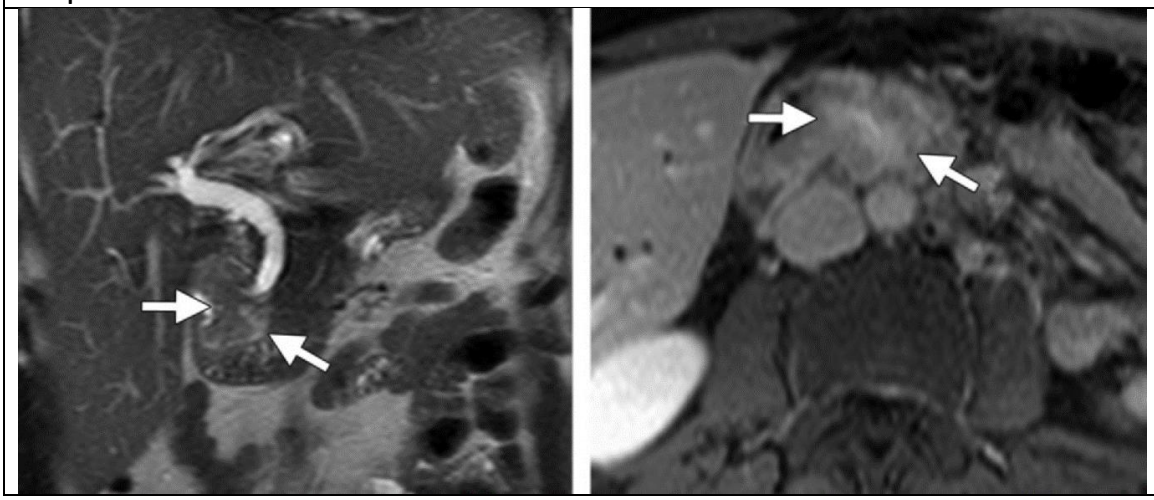
A. Ampullary tumors
B. Distal CBD tumors
C. Duodenal Adenocarcinoma (Periampullary portion)
D. Head & uncinate process of pancreas.

Ampullary Tumors

- The ampulla of Vater is located in the major duodenal papilla
- The ampulla of Vater represents the junction of the common bile duct (CBD) and main pancreatic duct of Wirsung
- The ampulla of Vater is surrounded by the sphincter of Oddi.
- Ampullary carcinoma is adenocarcinoma arising in the ampullary complex distal to the confluence of the pancreatic duct and CBD

Imaging finding:

- Small nodular ampullary mass
- Duodenal papillary bulging
- Irregular asymmetric luminal narrowing of the distal CBD
- Diffuse upstream intra- and extrahepatic biliary dilatation and pancreatic duct



Duodenal Adenocarcinoma

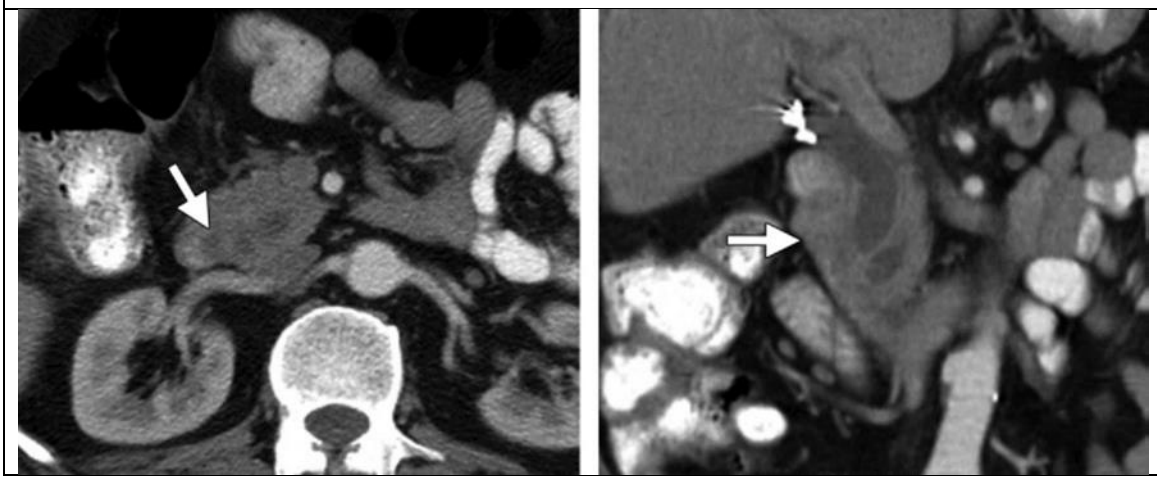
- is the most common primary malignancy of the duodenum.
- 50-70% of small bowel adenocarcinomas occurring either in the duodenum or proximal jejunum

Location

- Distal portion (3rd and 4th parts): 45%
- Second part: 40%
- First part: 15%

Imaging findings:

- CT demonstration of duodenal lesions facilitated by negative contrast agents (water):
- Intrinsic mass with a short segment of bowel wall thickening
- Invasion of retroperitoneal fat planes, pancreatic and biliary duct, vascular encasement
- Lymph nodal and distant metastases is common in later stages



Duodenal Injuries

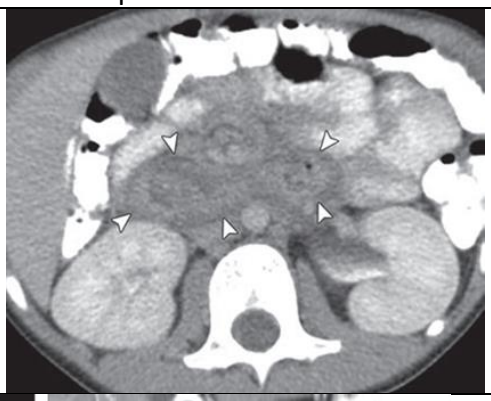
- Blunt abdominal trauma, non-accidental injury to children
- 3rd & 4th portions of the duodenum

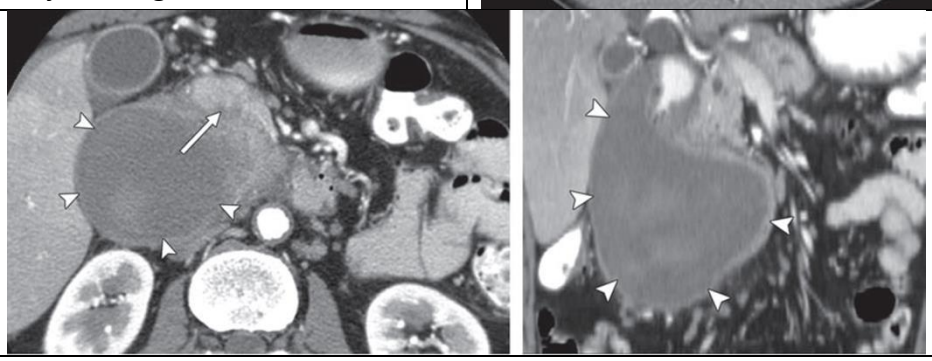
Duodenal injuries:

- Duodenal hematoma
- Partial-thickness lacerations
- Complex lacerations
- Massive disruption of the duodenopancreatic complex

Doudenal Hematoma:

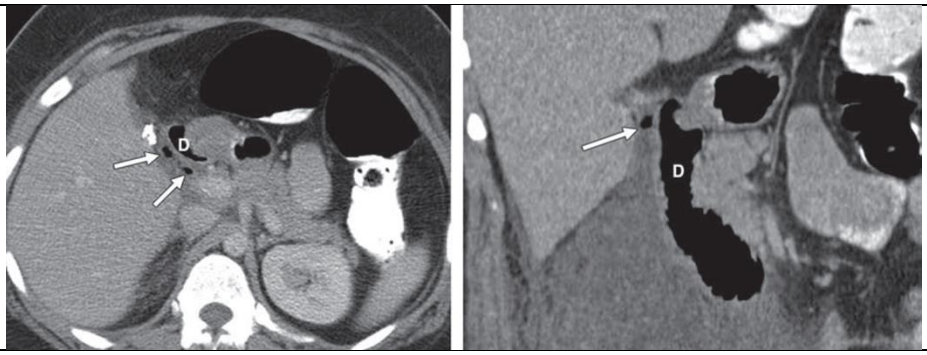
- Duodenal wall thickening > 4 mm
- Stranding of retroperitoneal fatty tissue
- Periduodenal fluid
- Fluid in the right anterior pararenal space
- Diminished bowel wall enhancement of the injured segment





Duodenal Perforation:

- Extra-luminal air
- Extra-luminal oral contrast material



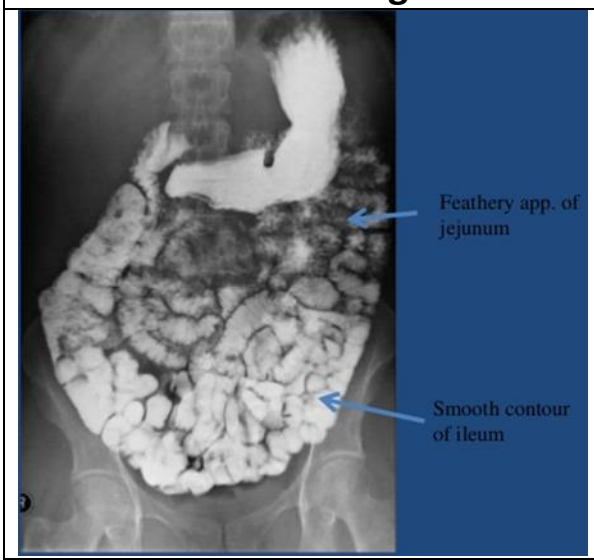
Small and Large Bowel

Anatomy

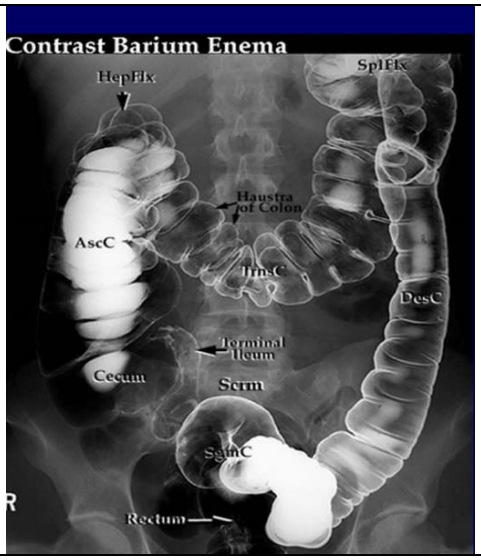
Differences between Jejunum & Ileum

Characteristic	Jejunum	Ileum
Color	Deeper red	Paler pink
Wall	Thick & heavy	Thin & light
Vascularity	Greater	Less
Arcades	A few large loops	Many short loops
Vasa recta / arteriae rectae	Long	Short
Fat in mesentery	Less	More
Circular folds (plicae circularis)	Large, tall & closely packed (valves of Kerkring)	Low & sparse; absent in distal part
Lymphoid nodules (Peyer's patches)	Few	Many

Barium Follow Through



Barium Enema



❖ Imaging Techniques

- **Barium follow through - Enema**
- **Endoscopy**
- **Capsule endoscopy**
- **CT Enterogrophy**
- **CT Colonography**
- **MR Enterography**
- **MR Colonography**

1) CT Enterography

2 Techniques:

- CT enterography is achieved by ingestion of neutral oral contrast agents.
- CT enteroclysis contrast medium is administered into the small intestine through a nasojejunal tube under fluoroscopic guidance

Advantages:

- NON invasive technique
- easy to perform
- Allow evaluation of :
    - Entire thickness of the bowel wall
    - Surrounding mesentery and perienteric fat.
    - Extra-enteric structures
    - Solid organs

Disadvantages

- Requisite exposure of patients to ionizing radiation,
- Of particular concern in young patients; the frequent need for repeated imaging;
- The necessity of using IV contrast material

Patient preparation

- GIT should be empty and clean, with the lumen distended
- Fasting 4 hours before the examination

Oral Contrast:

- Patients are given a total of 1200–2000 mL of neutral oral contrast agent (Diluted barium Sulphate):
    - CT enteroclysis = given through tube at a rate of 60–120 mL/min
    - CT enterography = Divided into 4 oral doses given every 20 min, beginning 60 min before scanning; the last dose is administered with the patient on the CT table just before scanning
- IV administration of a spasmolytic drug is essential before image acquisition to minimize patient discomfort and bowel motion artifact

IV Contrast:

- Type : iodinated contrast material
- Amount = 150 mL
- Rate = 4 mL/sec
- Site = antecubital catheter,
- Bolus triggering is performed by placing a region-of-interest cursor over the descending aorta 2 cm above the diaphragm.
- ROI trigger threshold is set at 150 HU.

Scanning Phases:

- Scanning is performed from the diaphragm to the symphysis pubis during each of 3phases:
    - Arterial phase: 20–25 seconds
    - Enteric phase: 45 sec
    - Delayed phase: 70–75 seconds
- Section thickness = 2.0 –2.5 mm
- Reconstruction interval = 1.0 –1.5 mm.

2) MR Enterography

2 Techniques

- MR enterography: enteric contrast material is administered orally.
- MR enteroclysis: enteric contrast material is administered through a nasoenteric tube.

- MR imaging also may be used for patients with contraindications to CT enterography, such as pregnancy, or with contraindications to the use of iodinated contrast material.

Patient Preparation:

- Fasting 6hrs
- Bowel cleansing
- Two days prior to the procedure, a low-fiber diet is started,

Oral contrast

- 1.5-2 L of oral contrast media.
- Mannitol in water solution (2%), which provides good contrast between lumen and bowel wall on both T1 and T2 sequences and is well accepted by patients.
- Spasmolytics are useful for reducing bowel peristalsis and motion artifacts.

MRI sequences

- Axial Balanced FFE
- Axial T2 FSE
- Axial T2 with fat sat
- Axial T1 pre-contrast

- Coronal Balanced FFE
- Coronal T1 pre-contrast

- Axial T1 post-contrast 3D GRE
- Coronal T1 post-contrast 3D GRE

- Diffusion Imaging (DWI).

3) CT Colonography & Virtual Colonoscopy

Patient preparation

- The colon should be clean and completely distended
- Residual stool and fluid may lead to a false negative or false positive diagnosis
- Residual stool may be "tagged" using oral contrast agents such as gastrografin

Bowel distension

- Distension can be achieved via a pressure-regulated device with carbon dioxide (preferred) or room air

Intravenous contrast

- not necessary although it is used in some centres

Anti-spasmodic agent

- IV/IM hyoscine-N-butylbromide (Buscopan), an anti-muscarinic drug reduces colonic motion, leading to higher quality images and reduced patient discomfort

Data acquisition and analysis

- CT scanning is ideally performed on a multi-detector computed tomography (MDCT) scanner in both supine and prone positions with a thin collimation
- Image review with the use of 2D and 3D displays is strongly advised for optimal evaluation

Contraindications

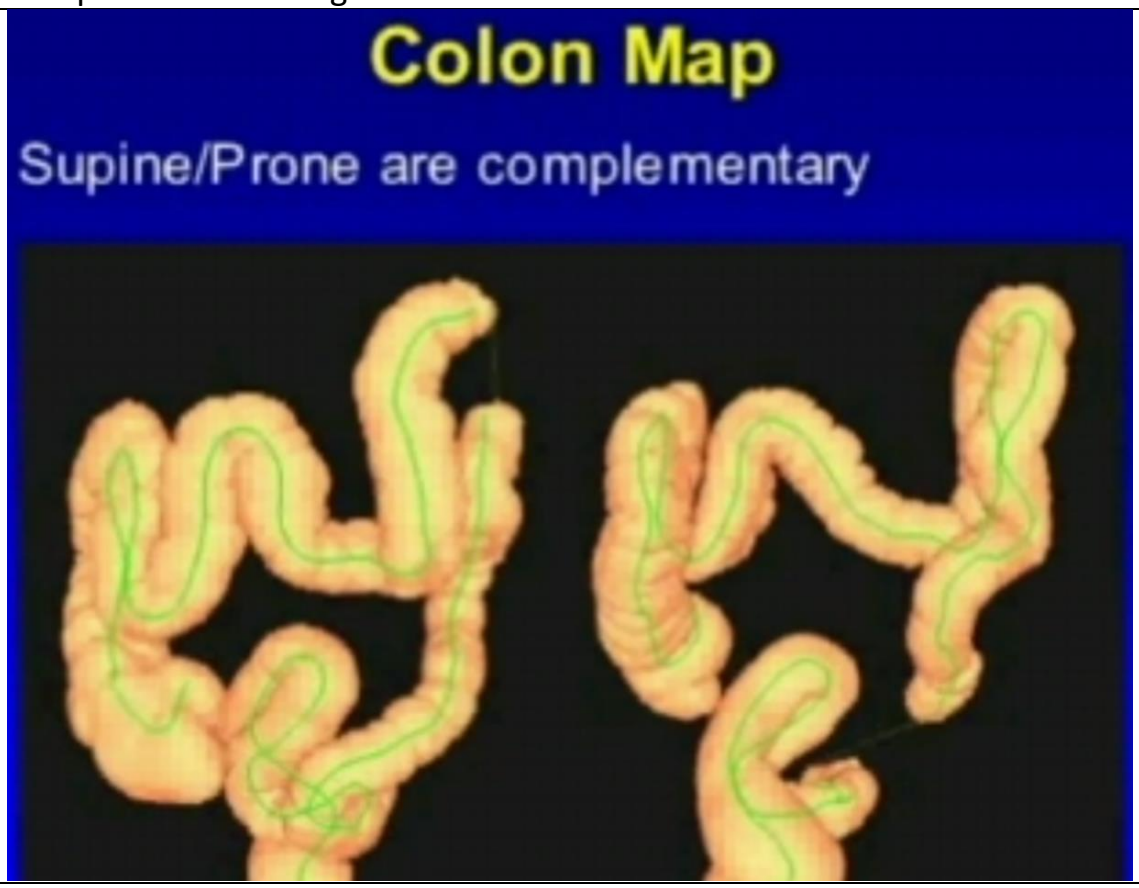
- Acute inflammatory conditions such as acute diverticulitis, active stage of ulcerative colitis or Crohn disease
- Recent abdominal or pelvic surgery
- CTC cannot be performed if a colostomy is present as there is no natural sphincter mechanism to retain the tube
- General CT contraindications e.g. Pregnancy, claustrophobia, etc
- History of severe allergy/anaphylaxis to iodinated contrast media

Advantages

- Virtual colonoscopy has several advantages over conventional colonoscopy:
- Minimally invasive procedure, therefore complication rate lower
- Takes less time
- Can visualise colon beyond the obstruction or narrowing
- Detects extracolonic pathology

Disadvantages

- Residual faecal material can give rise to wrong interpretation
- Biopsy specimen cannot be taken at the time of the procedure
- It is a screening procedure, if there is any positive finding with virtual colonoscopy, conventional colonoscopy is required for confirmation of diagnosis
- Exposure to ionising radiation



4) MR Colonography

Advantages:

- MR imaging provides multiplanar images with excellent soft-tissue contrast
- Minimally invasive techniques
- Lack of radiation exposure, which is relevant in young patients who need to be reassessed on multiple occasions over the course of these chronic conditions
- MR colonography also allows assessment of extraluminal complications

Patient Preparation:

- Bowel cleansing
- Two days prior to the procedure, a low-fiber diet is started, with the patient abstaining from food beginning the evening before the procedure.

Bowel distention:

- 1.5–2.5 L of warm water enema solution is introduced through a rectal probe.
- Water is a biphasic luminal contrast agent
- Antispasmodic agent

Bowel Wall Thickening

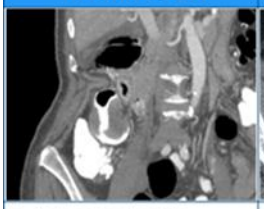
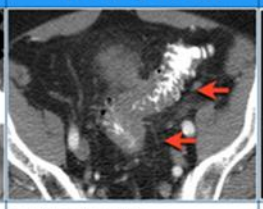
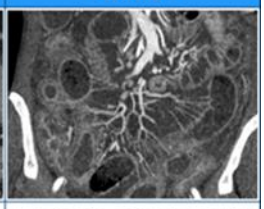
❖Normal CT Consideration of Bowel

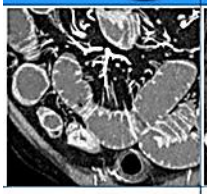
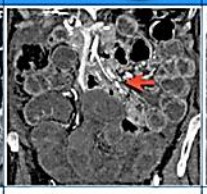
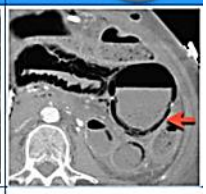
- Normal Colon:
  - Small Bowel: 3 cm
  - Large Bowel: 6 cm
  - Cecum: 9 cm
- Bowel wall thickness:
  - Normal: 3 mm
  - Distended: 1-2 mm

Bowel wall thickening

- Enhancement pattern

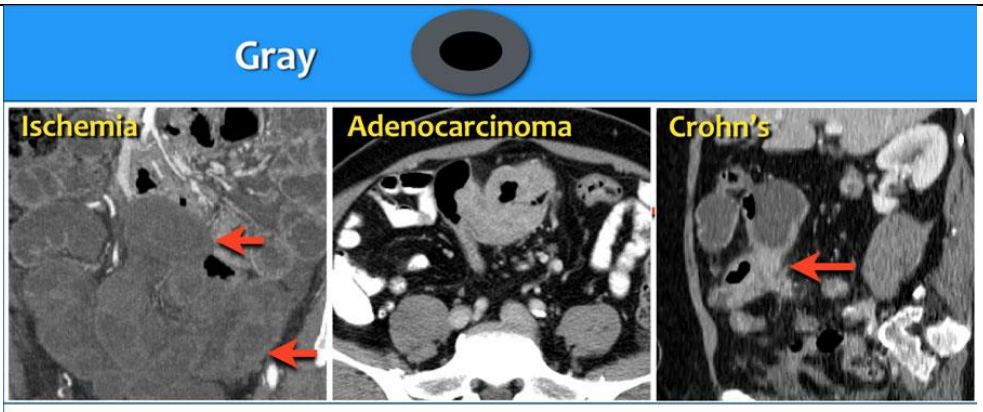
- Length of involvement
- Mural thickness
- Mesentery
  - Patency of mesenteric vessels
  - Edema
  - Lymph nodes
  - Fistula
- Lumen contents
  - Blood - Fat
  - Small bowel feces sign

Focal < 5 cm	Focal 5 - 10 cm	Segmental 10-30 cm	Diffuse
			
1. Adenocarcinoma	1. Diverticulitis 2. Crohn's disease 3. Ischemia	1. Ischemia 2. Submucosal hemorrh. 3. Radiation 4. Infection 5. Crohn's disease 6. Lymphoma	1. Infectious Enterocolitis 2. Ulcerative Colitis 3. Edema from low protein or cirrhosis 4. SLE

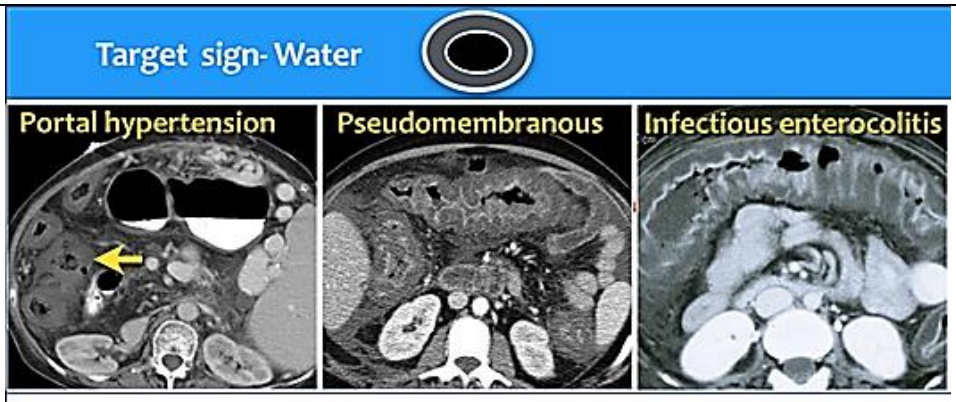
White	Gray	Target - Water	Target - Fat	Gas
				
1. **Acute IBD** due to vasodilatation with acute hyperemia 2. **Shock Bowel** injury to intramural vessels 3. **Reperfusion after ischemia** 4. **Hemorrhage**	1. **Chronic Crohn's** 2. **Ischemia** 3. **Neoplasm**	1. **Portal hypertension** 2. **Infection** - Shigella, Salmonella, E. Coli, CMV, Crypto - ***Pseudomemb. colitis*** - AIDS 3. **Acute Ulc. Colitis** 4. **Acute Crohn's** 5. **Typhlitis** 6. **AIDS** 7. **Ischemia**	1. **Chronic Ulc. Colitis** 2. **Chronic Crohn's** 3. **Obesity** 4. **Chemotherapy** 5. **Celiac disease**	1. **Ischemia** 2. **Infection** 3. **Trauma** 4. **Benign causes** - Connect tissue disease - IBD - COPD - Obstruction 5. **Pseudo-pneumatosis**

White

1. **Acute IBD**
   due to vasodilatation with acute hyperemia
2. **Shock Bowel**
   injury to intramural vessels
3. **Reperfusion after ischemia**
4. **Hemorrhage**

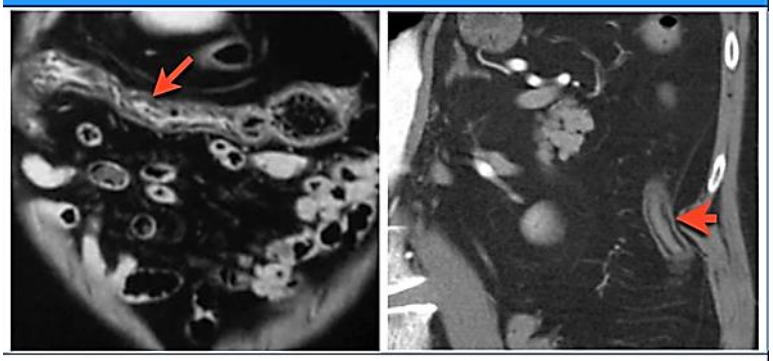


1. Chronic Crohn's
2. Ischemia
3. Neoplasm



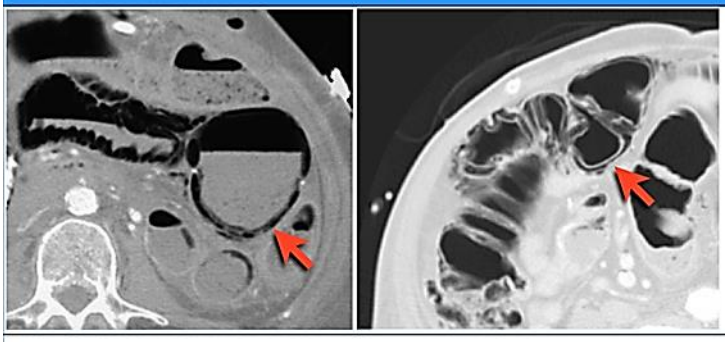
1. Portal hypertension
2. Infection
   - Shigella, Salmonella, E. Coli, CMV, Crypto
   - *Pseudomemb. colitis*
   - AIDS
3. Acute Ulcerating Colitis and Acute Crohn's
4. Typhlitis
5. AIDS
6. Ischemia

Target - Fat



1. **Chronic Ulc. Colitis**
2. **Chronic Crohn's**
3. **Obesity**
4. **Chemotherapy**
5. **Celiac disease**

Gas



1. **Ischemia**
2. **Infection**
3. **Trauma**
4. **Benign causes**
   - Connect tissue disease
   - IBD
   - COPD
   - Obstruction
5. **Pseudo-Pneumotosis**

❖ Differential Diagnosis

- **Inflammation:**
  - **Primary: Inflammatory bowel disease**
  - **Collagen Vascular Disease: SLE – Scleroderma**
  - **GVHD**
  - **Radiation enteritis**
  - **Chemotherapy induced enteritis**
  - **Inflammatory Pseudotumor**
- **Infection:**
  - **Bacterial: E.coli, Shigella, Salmonella, Yersinia, Campylobacter and Staphylococcus.**
  - **Viral: Rotavirus, Herpes, and Cytomegalovirus.**
  - **TB**
  - **Parasitic**
  - **Pseudomembranous Colitis.**
- **Bowel ischemia:**
  - **Mesenteric ischemia**
  - **Cardiac**
  - **Vasculitis**
- **Bowel edema**
- **Bowel hemorrhage**
  - **Shock bowel Syndrome**
  - **Henoch-Schönlein purpura**
- **Malignancy**
  - **Adenocarcinoma**
  - **GIST**
  - **Lymphoma**
  - **Neurogenic Tumors**
  - **Vascular Tumors**

I- Inflammatory Bowel Disease

A- Crohn Disease

- is an idiopathic chronic inflammatory disease of the GIT
- Relapsing and remitting nature requires frequent imaging examinations to monitor disease activity and severity
- Age = 2nd–4th decades of life.

Etiology:

- ***Multifactorial***: with genetic, immunologic, infectious, microvascular, and possibly environmental and lifestyle factors contributing.

Distribution:

- Any part of GIT from the mouth to the anus.
- Segmental and Transmural inflammation.
- The small intestine is involved in 80% of cases, most commonly at the terminal ileum.
- The colon is affected either with (50% of cases) or without (15%–20%) involvement of the small intestine

Role of imaging:

- Differentiate active inflammatory strictures from fibrotic strictures in order to guide therapy.
- Active bowel disease => treated medically,
- Fibrotic strictures => surgery and strictureplasty.

3 Stages:

i. ***Active inflammatory***
ii. ***Fibrostenotic disease.***
iii. ***Penetrating.***
iv. ***Extra-enteric Complications***

i- Active Inflammation

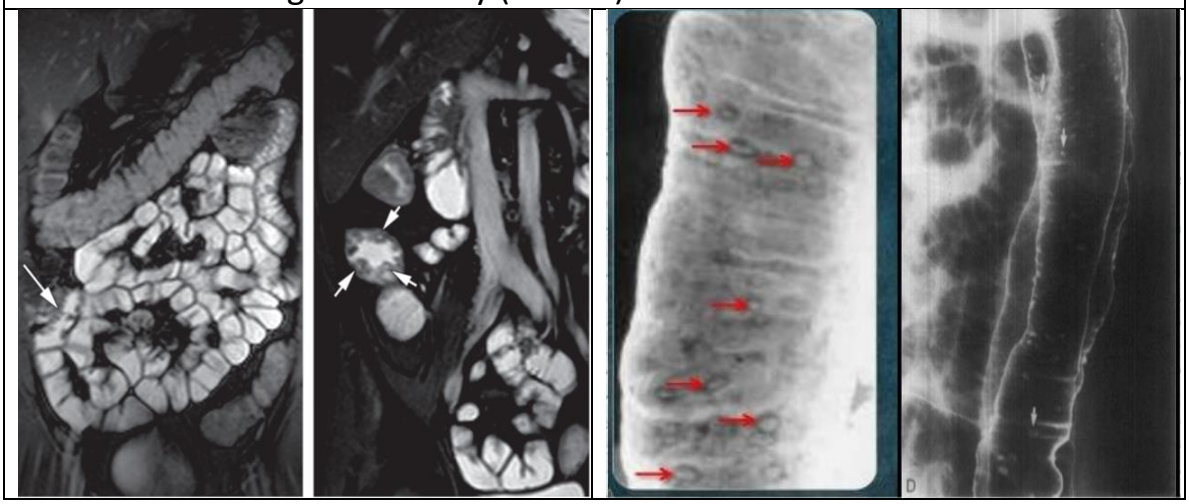
- **Aphthous ulcers.**
- **Cobblestoned appearance**

- **Bowel wall thickening > 3mm**
- **Mural stratification (Water Target sign).**
- **Mucosal/Mural/Layered hyperenhancement**

- **Mesenteric fat stranding**
- **Engorged vasa recta = Comb sign**
- **Mesenteric Lymphadenopathy**

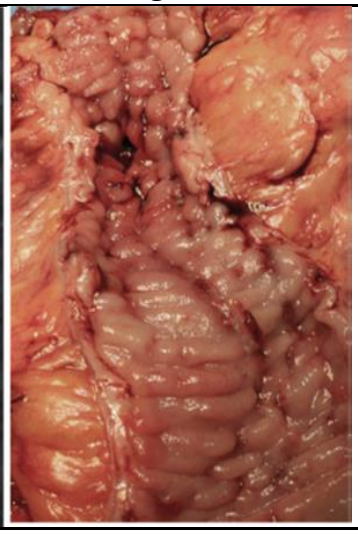
1) Aphthous Ulcers:

- Shallow mucosal erosion on the surface of hyperplastic lymphoid follicle surrounded by small hallow of edema
- MRI: nidus of high signal intensity (an ulcer crater) surrounded by a rim of moderate signal intensity (edema).



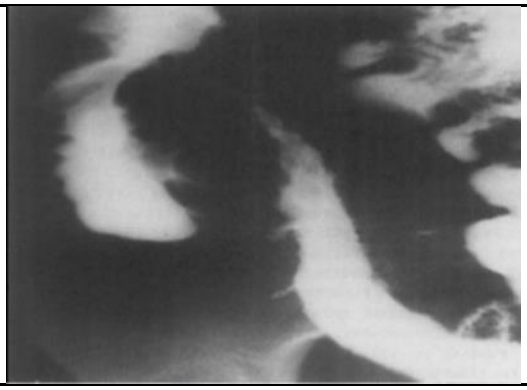
2) Cobblestoned Appearance

edematous mucosa between longitudinal and transverse linear ulcers



3) Raspbery Thorn Ulcers

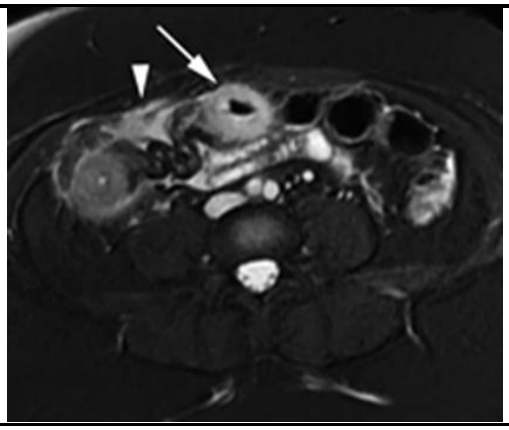
Fissuring Ulceration

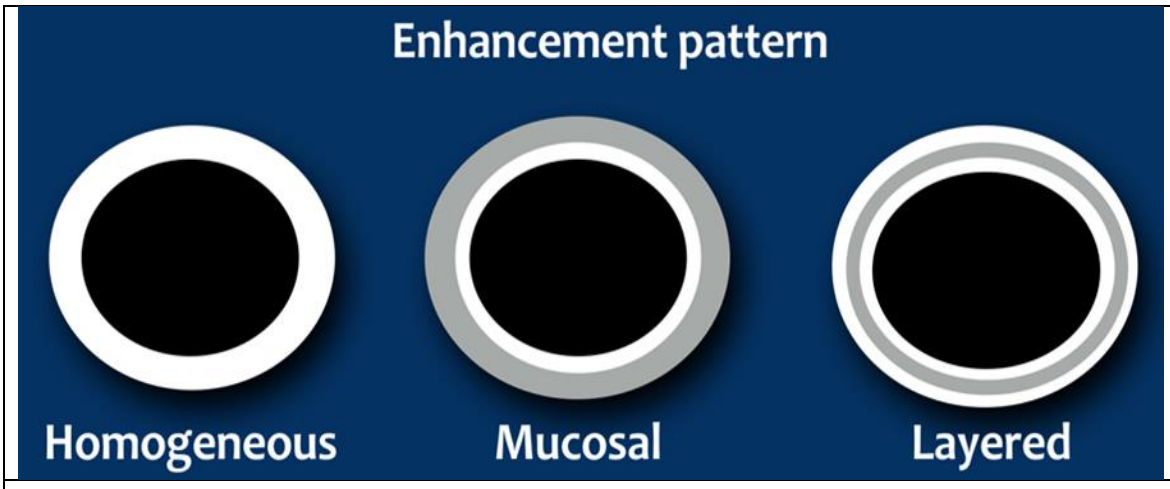


4) Wall thickening + Submucosal edema

Wall thickening > 3mm
↑ signal intensity on T2 FS

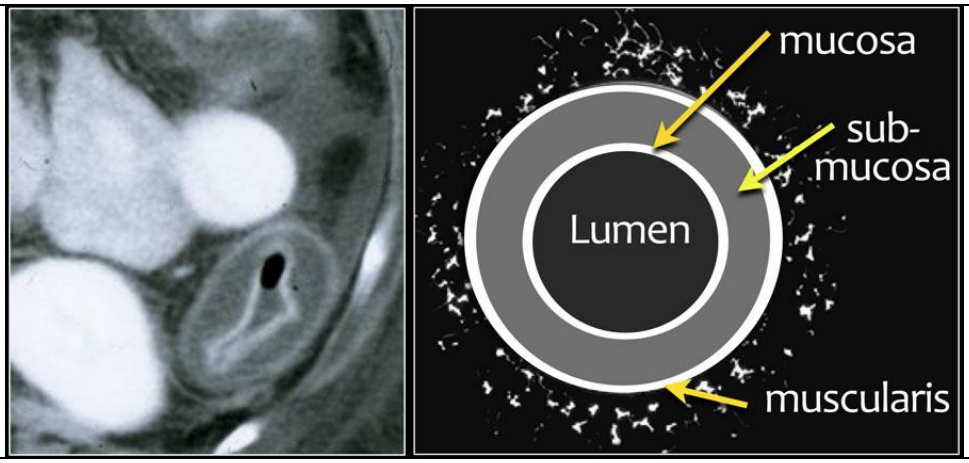
- The presence of intramural edema (or water attenuation) indicates active inflammation
- The presence of intramural fat indicates past or chronic inflammation



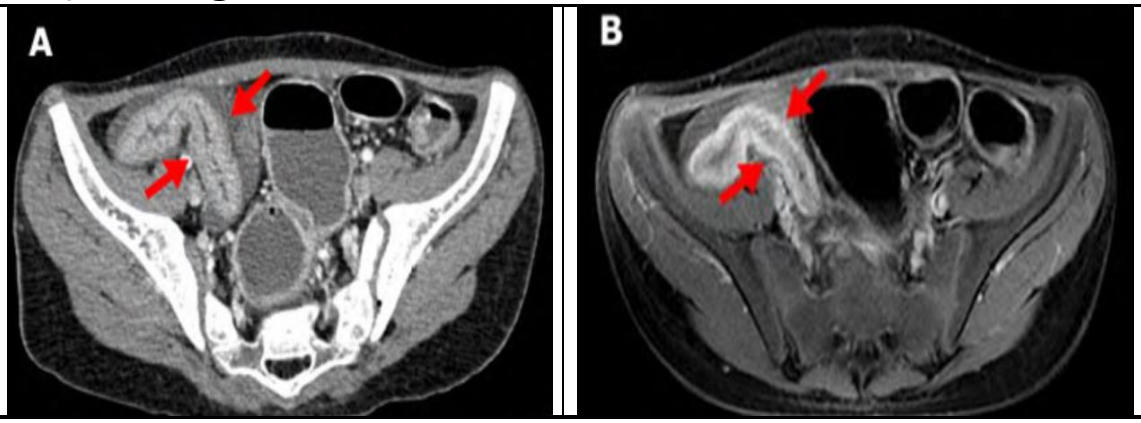


5) Stratified Contrast Enhancement

Water target sign is caused by the enhancing mucosa and muscularis propria with the edematous submucosa in between

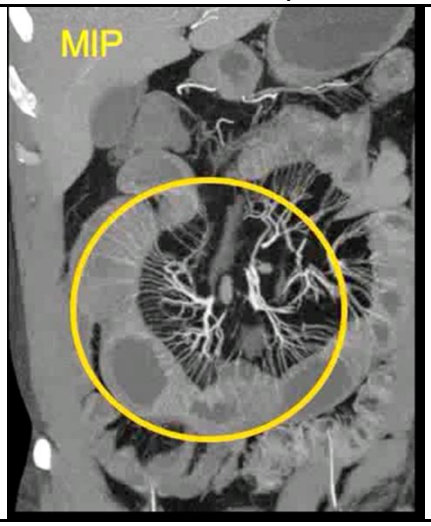


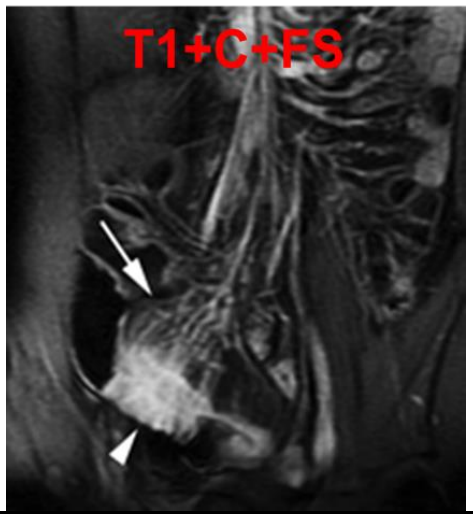
6) Homogeneous bowel wall enhancement



7) “Comb” Sign

Engorged vasa recta with increased mesenteric vascularity adjacent to the inflamed bowel loop





8) Mesenteric Lymphadenopathy

Mesenteric LNs
Short axis <1cm

ii- Fibrostenosing Disease

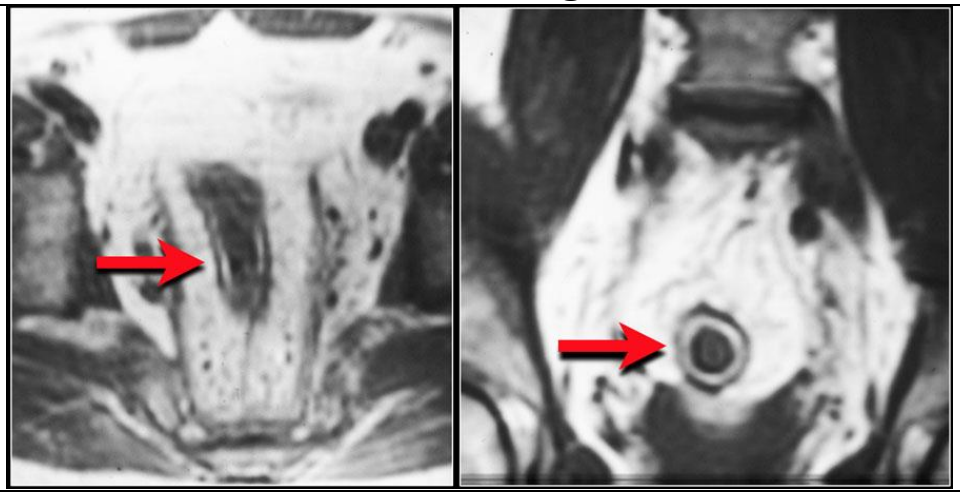
- **Fibrotic stricture = Mural thickening + Lumen narrowing**
- **NO mural edema = No stratification = NO high T2 signal**
- **NO enhancement**
- **Fat halo sign = fat target sign = Submucosal fat deposition**
- **Fat creeping = Fat wrapping = increased mesenteric fat**
- **Pseudosacculations**
- **Obstruction = Bowel dilatation proximal to a fixed, narrowed segment.**
- **Fecalization of the small-bowel contents**

1) Fibrotic stricture

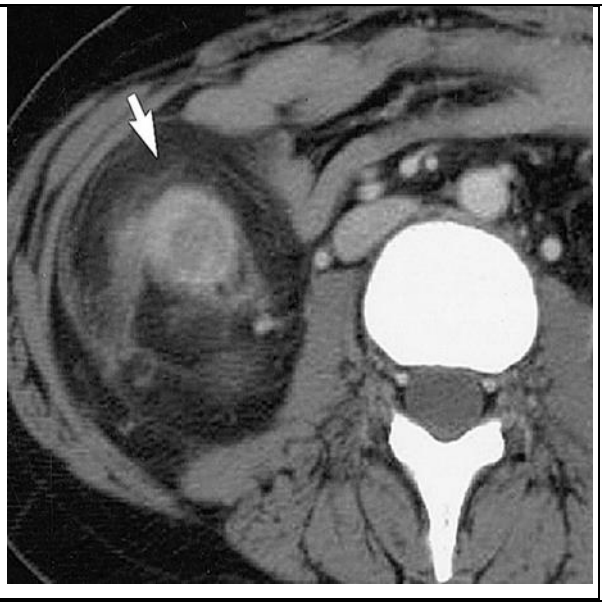
- The thickened submucosa of a strictured, fibrotic bowel segment
- NO high T2 signal
- NO enhancement

- **<u>Reversible strictures: Active disease</u>** => mucosal hyperenhancement, mural stratification, fat stranding, and engorgement of the vasa recta;
- **<u>Irreversible stricture: Fibrotic stage</u>** => lack of enhancement and loss of stratification might be seen in the presence of transmural fibrosis
- It is important to differentiate between reversible and irreversible strictures because the former warrant medical management, whereas the latter may require surgical intervention

2) Submucosal Fat = Fat halo sign:

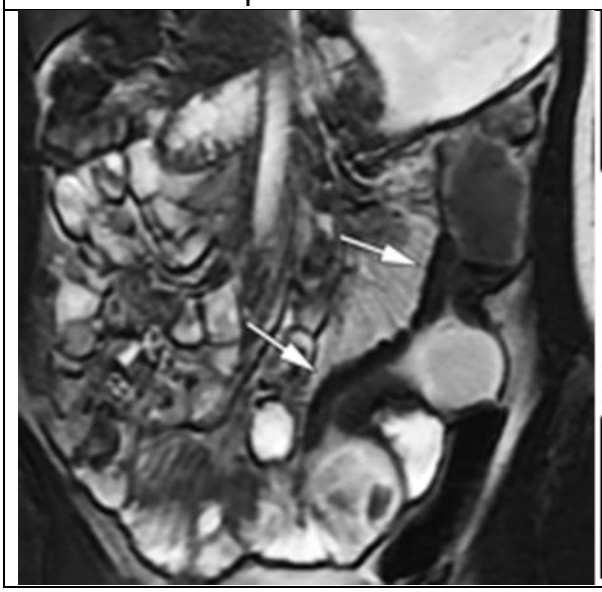


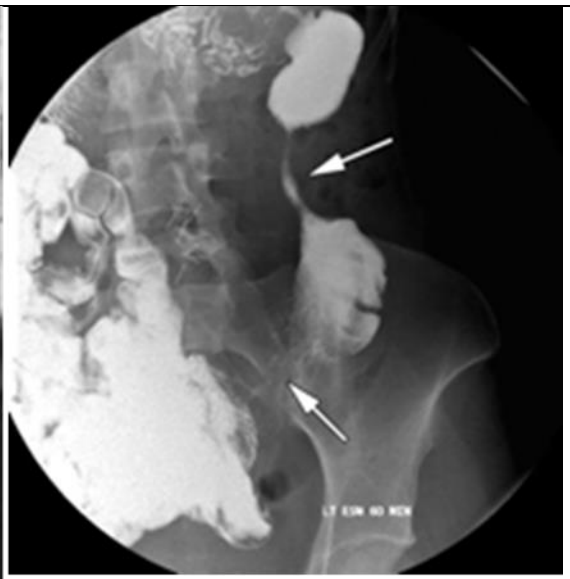
3) Fibrofatty proliferation



4) Pseudosacculation

- caused by asymmetric bowel fibrosis and shortening secondary to ulceration of the mesenteric side of the bowel,
- Causes pseudosaccules to form on the antimesenteric side.
- This asymmetric dilatation of the bowel also is referred to omega sign
- These changes are well depicted on coronal images along the mesenteric plane.

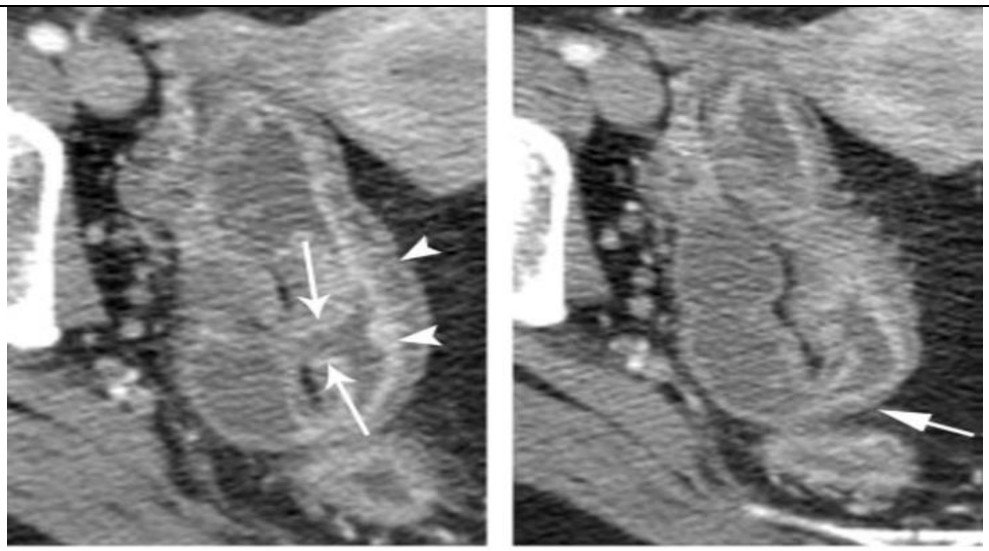




iii- Penetrating Disease

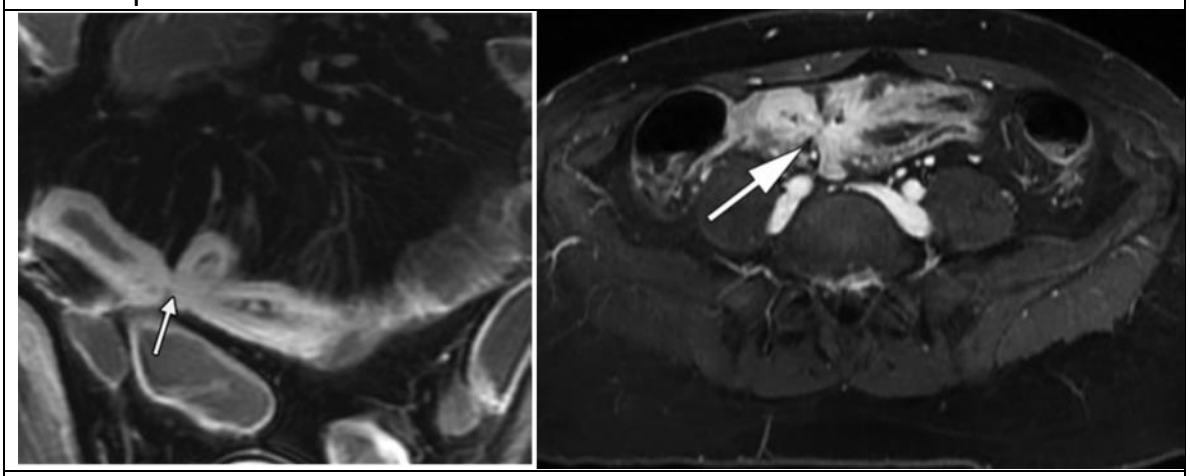
- **Fistulas**
- **Sinus Tracts**
- **Abscesses**

1) Ileo-ileal Fistula

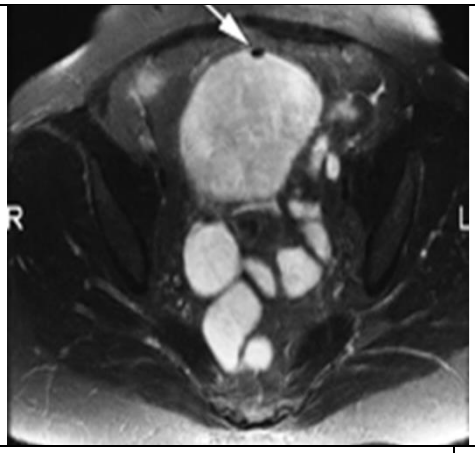


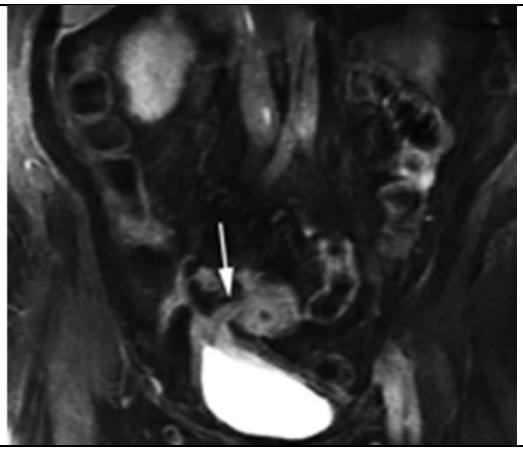
2) Enteroenteric Fistula

Stellate appearance = multiple tracts and bowel loops radiating from the central portion.

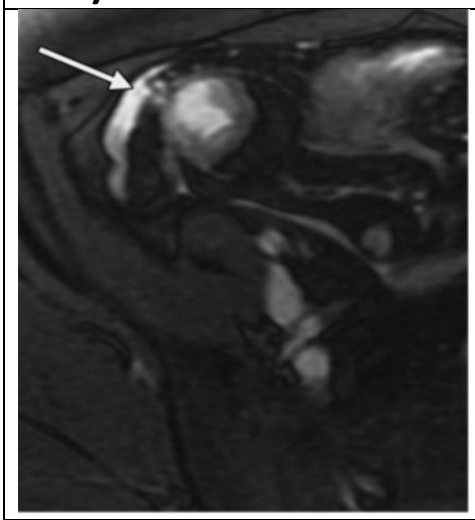


3) Enetrovesical Fistula

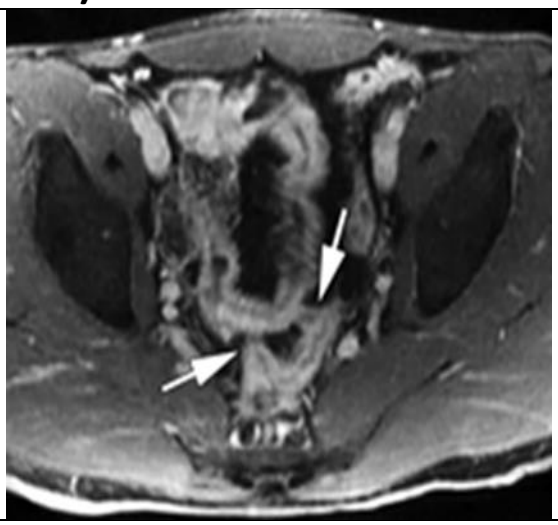




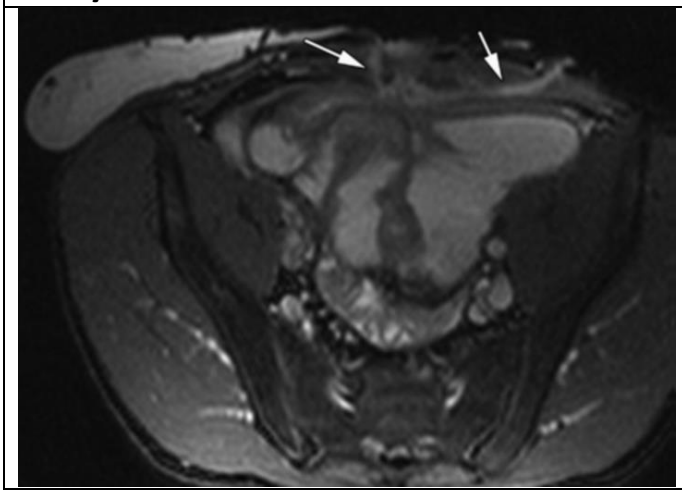
4) Ileocecal Fistula



5) Ileo-colic Fistula

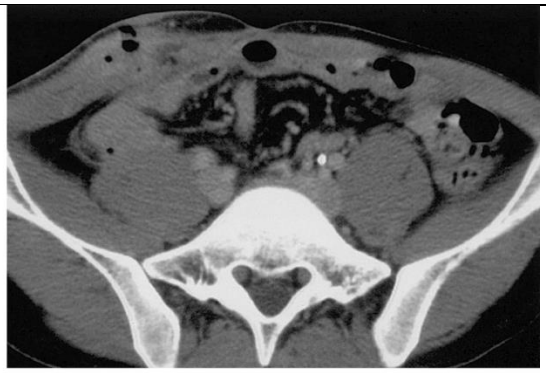


6) Enterocutaneous Fistula



7) Abscess

13.



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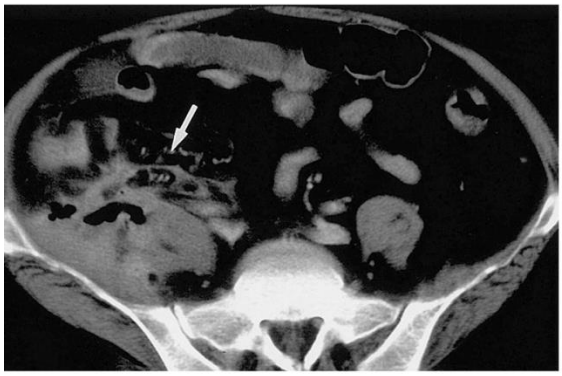

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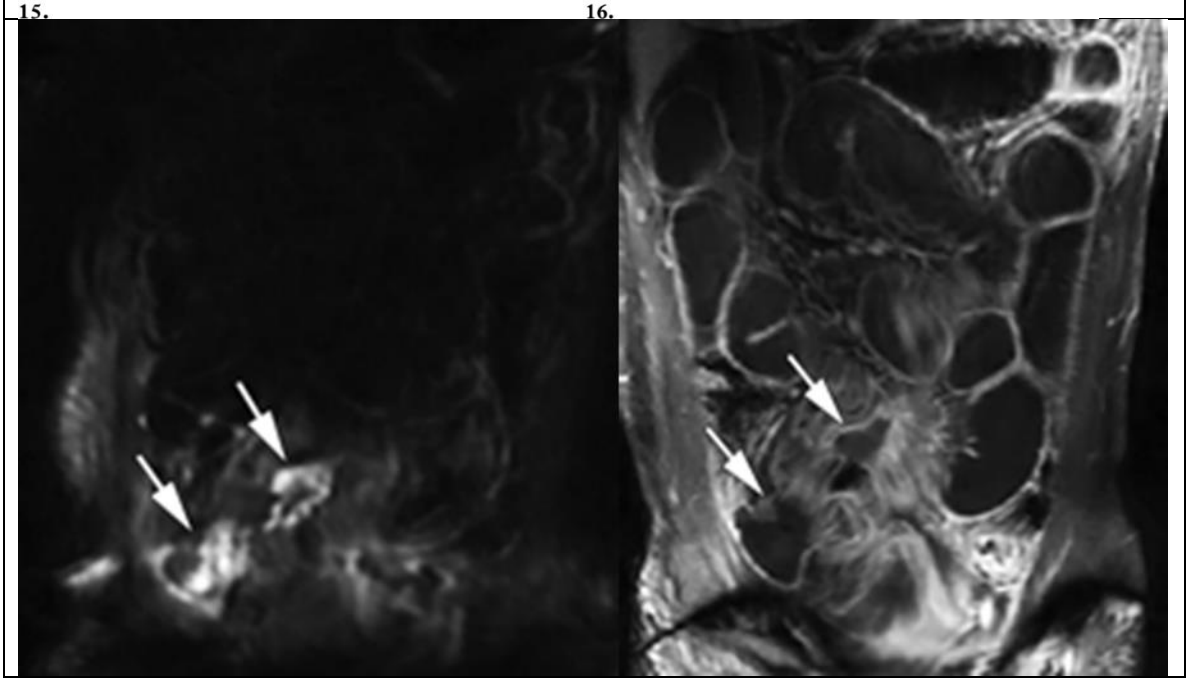
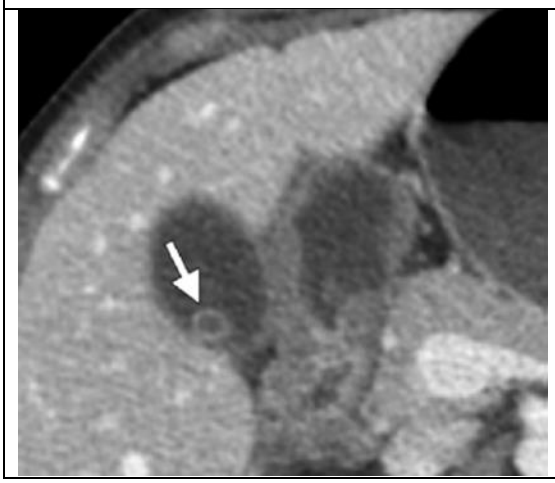
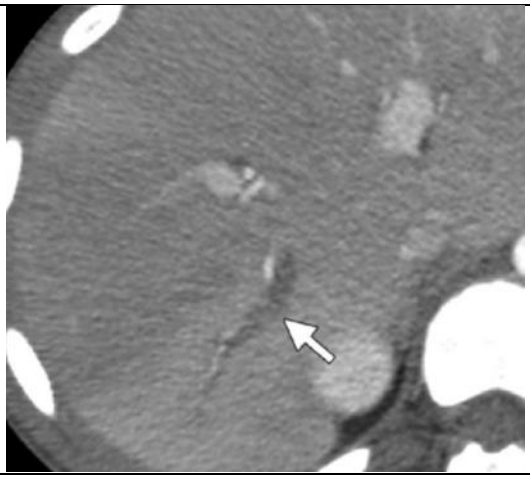


iv- Extraenteric Complications Of Crohn Disease

- **Sacroiliitis**
- **Renal stones**
- **Cholelithiasis**
- **Primary sclerosing cholangitis**
- **Lymphoma.**

Gall Bladder Stone	Primary Sclerosing Cholangitis
	

B-Ulcerative Colitis

- Idiopathic, chronic inflammatory disease that involves the mucosa of the rectum and colon.
- Characteristically, inflammation spreads from the rectum proximally to involve the colon + NO skip lesions + may extend to the terminal ileum“backwash ileitis”

Distribution:

- ✓ Rucum only => proctitis
- ✓ Rectosigmoid => most common
- ✓ Whole colon => pancolitis
- ✓ Terminal ileum => Back wash ileitis

i- Active Phase

- Mucosa => irregular mucosal surface with Granular mucosa + ulcers
- Muscularis mucosa and submucosa => spared.
- Wall thickening
- Mural edema
- Inflammatory pseudopolyps.
- Hyperenhancment
- Engorged vasa recta
- Enlarged hyperenhancing pericolonic lymph

ii- Chronic Inactive Disease

- Mural thickening,
- Loss of haustrations
- Luminal narrowing
- Fatty proliferation in ulcerative colitis is typically limited to the perirectal space, producing an enlarged presacral space.

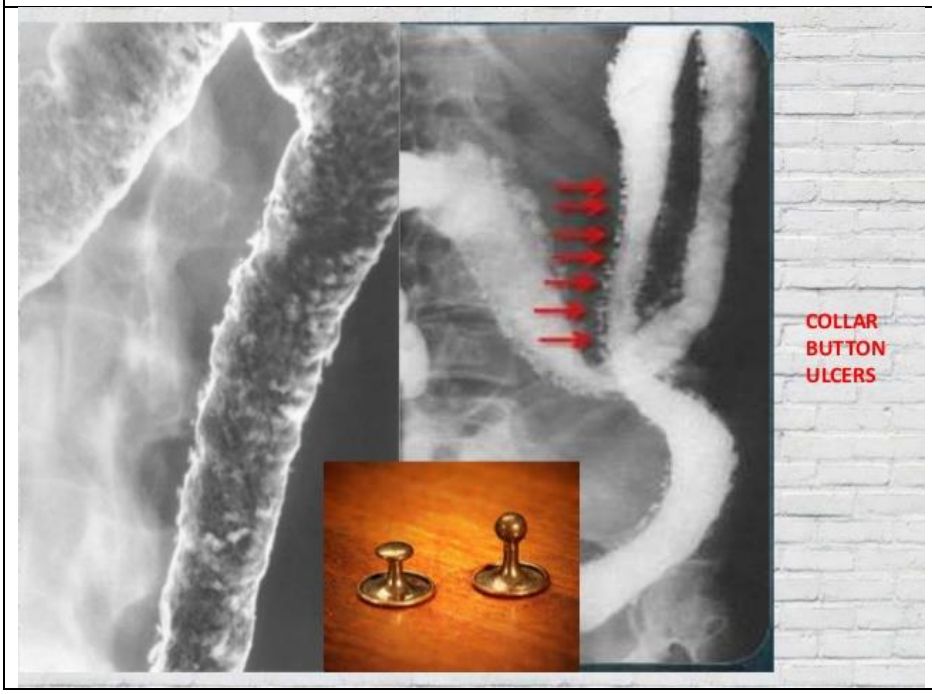
iii- Complications

- Pseudopolyp formations
- Mural thinning, pneumatosis, and perforation may be detected in cases of toxic megacolon.
- Rectal narrowing and presacral fat accumulation.
- Rectal carcinoma

Colonoscopic and MR Colonographic Findings in Crohn Disease

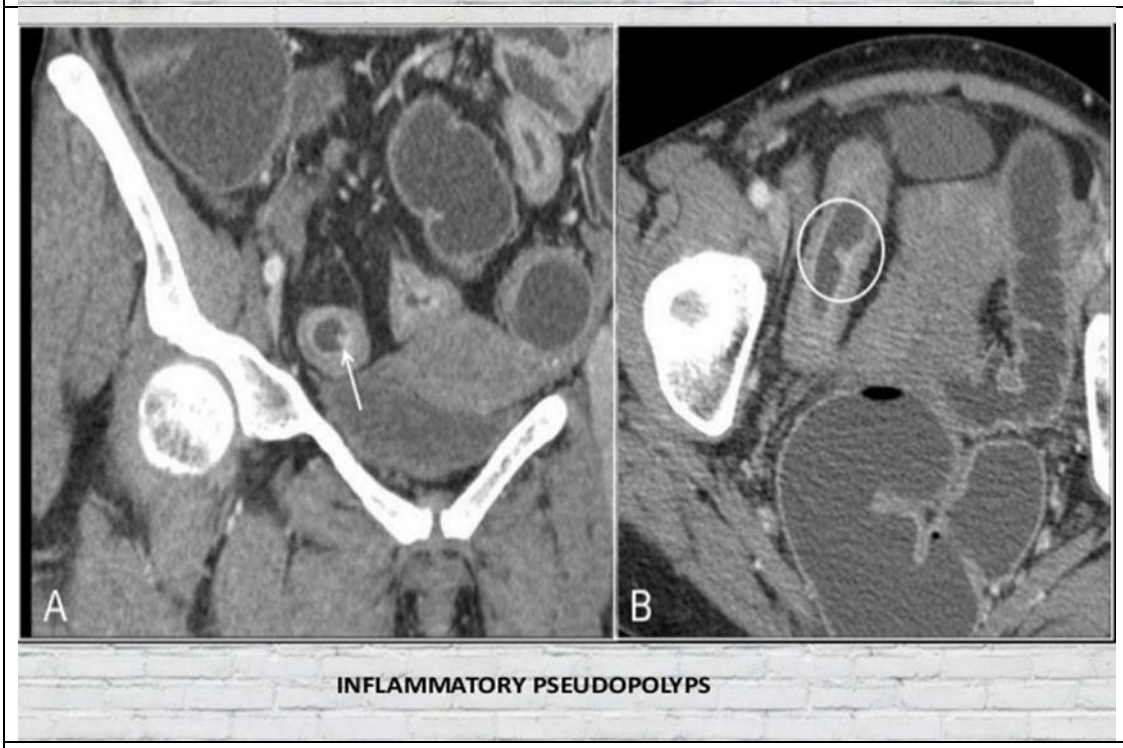
Disease Stage	Colonoscopic Findings	MR Colonographic Findings
Active		
Mild	Patchy erythema, loss of vascular pattern, aphthoid ulcers (ring-shaped flat protuberances)	Mild thickening of colonic wall, infrequent mucosal alterations, reduced distensibility of colonic wall
Moderate to severe	Ulcers of varying size and depth, coarsely nodular changes of colonic wall (cobblestone pattern), fistulous orifices (rare)	Large coalescent deep ulcers, moderate or severe mural edema and thickened wall, loss of haustra, polypoid lesions (cobblestone pattern), hyperenhancement after intravenous contrast material administration, vascular dilatation, enlarged regional lymph nodes (<1 cm), fistulous tracts, abscesses
Long-standing chronic inactive	No mucosal alterations, tubular shape of lumen, loss of haustra or thickening of haustral folds, postinflammatory pseudopolyps, solitary giant polyps, stenosis	No mucosal alterations, tubular shape of lumen, loss of haustra, fibrofatty proliferation (mural or regional)

- Fine mucosal granular pattern (edema/hyperemia)
- Mucosal stippling: Punctate barium collections (crypt abscesses erode ~ ulcers & barium collection)
- ***Collar Button Ulcers***



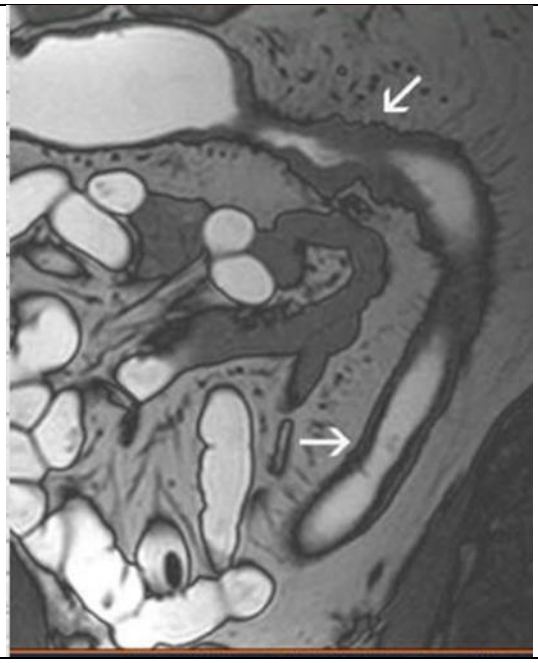
Pseudopolyps

Pseudopolyps in ulcerative colitis Double contrast barium enema demonstrates mucosal pseudopolyps (arrows) and a stricture arising in the descending colon. Courtesy of Norman Joffe, MD.

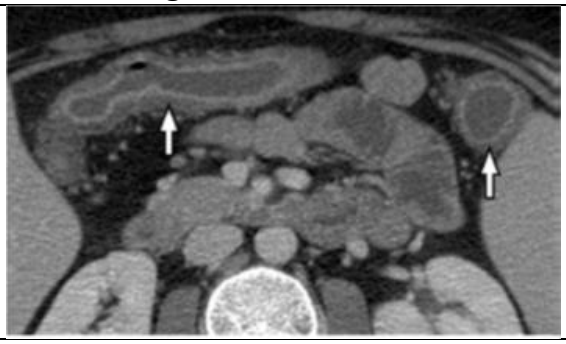
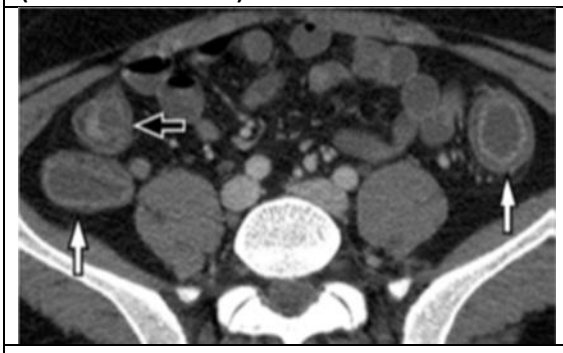
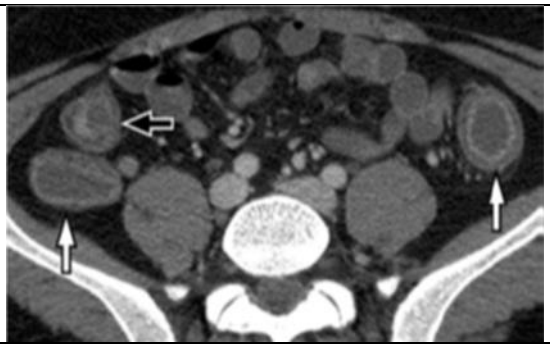


INFLAMMATORY PSEUDOPOLYPS

Lead Pipe Colon

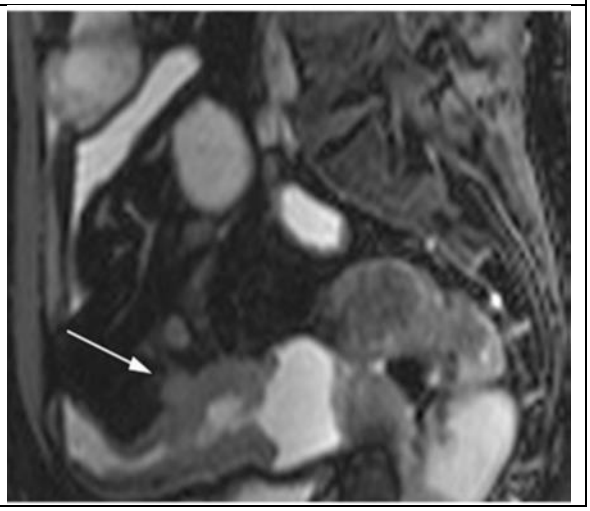


Wall thickening and enhancement

Rectum + Sigmoid	Descending + Tr Colon
	
Ascending + descending colon (White arrows)	Bacwash ilitis (Black arrow)
	

❖ Colorectal Cancer Complicating IBD

- The risk of colon cancer increases with time after 10 years duration of IBD.
- Ulcerative Colitis >> Crohn disease.
- Patients with IBD undergo periodic screening
- Colonoscopy for the early diagnosis of colorectal cancer



Other Inflammatory Bowel Diseases

1) Sprue

- Sprue is the collective term for the **malabsorbative** gastrointestinal enteropathies.
- It is composed of three entities:
  - **Tropical sprue**
  - **Non-tropical sprue**
  - **Coeliac disease**

- The radiologic features are not sensitive enough to confirm diagnosis.
- Duodenal biopsy (gold standard).

❖ Coeliac disease

- = (non tropical sprue) is a condition of gastrointestinal malabsorption (sprue) that results from the small intestine's response to dietary gluten.
- It should always be considered as the possible underlying aetiology in cases of Iron deficiency anaemia of uncertain cause.

Age

- Childhood by age of 2 years
- 2nd peak in 3rd & 4th decades

Pathology

- The villous atrophy that occurs within the bowel results in malabsorption of iron, folic acid, calcium and fat soluble vitamin resulting in a variety of signs, some of which may be non-specific.
- The gold standard diagnostic test is a duodenal biopsy taken at UGIE.
- Serum endomysial antibodies may be raised

Complications:

- Increased risk of malignant conditions such as small bowel lymphoma (mainly T cell type) and small bowel adenocarcinoma.
- Hyposplenism
- Ulcerative jejuno ileitis
- Increase risk of development of carcinoma of oesophagus
- Cavitary lymph node syndrome

Fluoroscopy (Barium follow through)

- Small intestinal dilatation
- Non-obstructing intussusception
- Ileojejunal fold pattern reversal
- Featurless jejunum
- jejunalisation of the ileum
- Moulage sign is a dilated loop of bowel with effaced folds. It is said to appear like a tube into which wax has been poured:
- Mosaic pattern
- Flocculation
- Segmentation

CT enterocolysis

- Reversed jejunoileal fold pattern : thought to have the highest specificity is considered the most discriminating independent variable for the diagnosis of uncomplicated coeliac disease
- Ileal fold thickening
- Vascular engorgement
- Splenic atrophy

2) Whipple disease

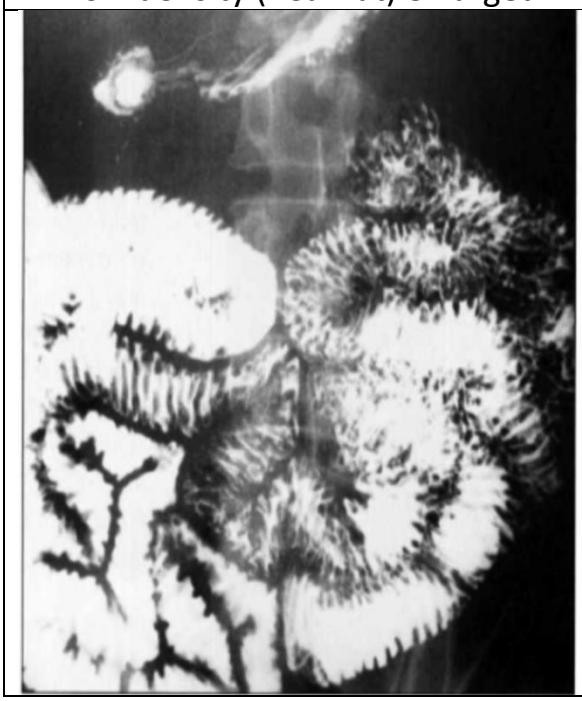
- Whipple disease is a rare infectious multi system disorder by the actinobacterium tropheryma whipplei.
- Age: Fifth decade
- Whites are most often affected
- Men > women
- Leading to chronic diarrhea & malabsorption

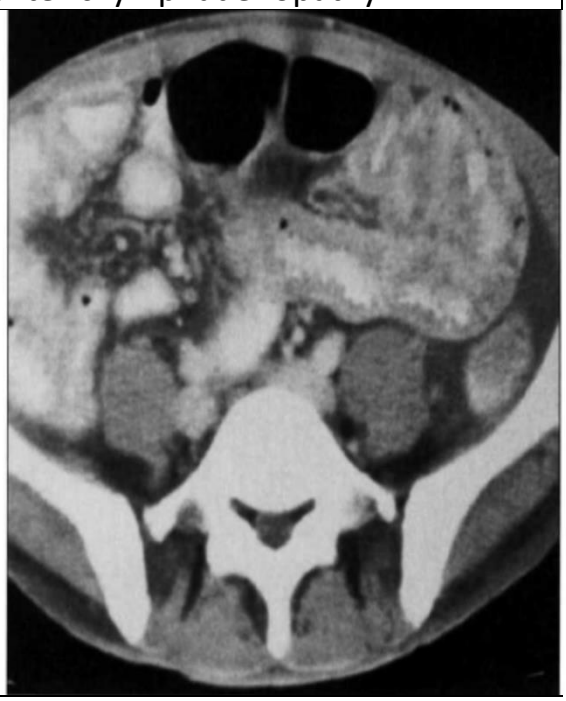
Location:

- The small bowel (intestinal lipodystrophy) is a classical location although the disease can affect a multitude of other organ systems with or without small bowel involvement.
- Skin – Joints - Central nervous system - Mediastinum

Imaging findings:

- Diffuse micronodules in jejunum (sand-like nodules)
- Thickened mucosal folds - especially of the jejunum
- Small bowel may be normal or slightly dilated
- Low density (near fat) enlarged mesenteric lymphadenopathy





3) Scleroderma

- Scleroderma (also known as systemic sclerosis) is a multi-system autoimmune connective tissue disorder. As such, it affects many separate organ systems, which are discussed separately:
- Gastrointestinal manifestations of scleroderma can occur in up to 90% of patients with scleroderma with the commonest site of GI involvement being the oesophagus

Esophagus:

- 80% of scleroderma cases.
- Symptoms include heartburn and dysphagia.
- Dilatation of distal 2/3 of the oesophagus
- Apparent shortening of length due to fibrosis
- Dysmotility of lower oesophagus (normal peristalsis above aortic arch)
- Gastro-oesophageal reflux due to reduced sphincter tone
- Air-fluid level in oesophagus when supine (CT)

Stomach:

- Gastric involvement is relatively uncommon, but can result in delayed gastric emptying with or without gastric dilatation. Gastric vascular antral ectasia (dilated submucosal capillaries), often known as watermelon stomach, may also occur.

Small bowel

- 60% of scleroderma patients,
- Duodenum most frequently.
- Patients may be asymptomatic or may present with bloating or malabsorption due to bacterial overgrowth.
- Luminal dilatation (can be massive)
- Reduced peristalsis / delayed contrast transit
- Mucosal folds appear relatively normal despite dilatation
- Hidebound bowel sign (crowding of valvulae conniventes): thought to be pathognomonic of scleroderma
- Accordian sign: well seen evenly spaced mucosal folds in duodenum
- Sacculation (antimesenteric border, focal dilatations, pseudo-diverticula)

Large bowel:

- 40% of patients
- Constipation or diarrhoea. Reduced anal sphinter tone can result in faecal incontinence.
- Pseudosacculation
- Loss of haustration
- Colonic dilatation
- Reduced colonic transit time

4) SLE

Esophagus

- Hypomotility of the distal third of the esophagus is seen in 13%–32% of SLE patients, predisposing them to reflux esophagitis

Gall bladder:

- Acute cholecystitis
  - not related to gallstones
  - but rather to periarterial fibrosis and acute vasculitis that occur with elevated levels of circulating immune complexes

Pancreas

- Pancreatitis
  - can be focal or diffuse
  - may be due to vasculitis, ischemia of small pancreatic vessels, immune complex deposition, or a combination of these entities

Bowel Ischemia

  - due to SLE vasculopathy, particularly in the distribution of SMA
  - Mural thickening + thumbprinting due to bowel wall edema or intramural hemorrhage;
  - in more advanced stages, pneumatosis or portal venous gas

Imaging Findings in SLE

System	Components	Manifestations
Respiratory	Pleura	Effusion, pleuritis, fibrosis
	Parenchyma	Infection, hemorrhage, pneumonitis, fibrosis (mild)
	Pulmonary vasculature	Pulmonary arterial hypertension, pulmonary embolism
	Diaphragm	Diaphragmatic dysfunction
	Lung	Pulmonary infection
Cardiovascular	Myocardium	Myocarditis
	Pericardium	Effusion, pericarditis
	Valves	Valvulitis, Libman-Sacks endocarditis
	Vasculature	Atherosclerosis (arteries), vasculitis
Gastrointestinal	Esophagus	Hypomotility, reflux esophagitis
	Gallbladder	Acalculous cholecystitis
	Pancreas	Pancreatitis
	Bowel	Ischemia, vasculitis, edema
Genitourinary	Kidneys	Glomerulonephritis, nephrotic syndrome
	Vasculature	Renal vein thrombosis
Musculoskeletal	Joints	Arthritis
	Ligaments	Laxity, instability
	Bone	AVN, infarction, insufficiency fracture, osteomyelitis
Neurologic	Cerebral vessels	Vasculitis, dural venous sinus thrombosis
	Brain	Cerebritis, intracranial hemorrhage, infarction, infection

5) Neutropenic Colitis = Typhlitis

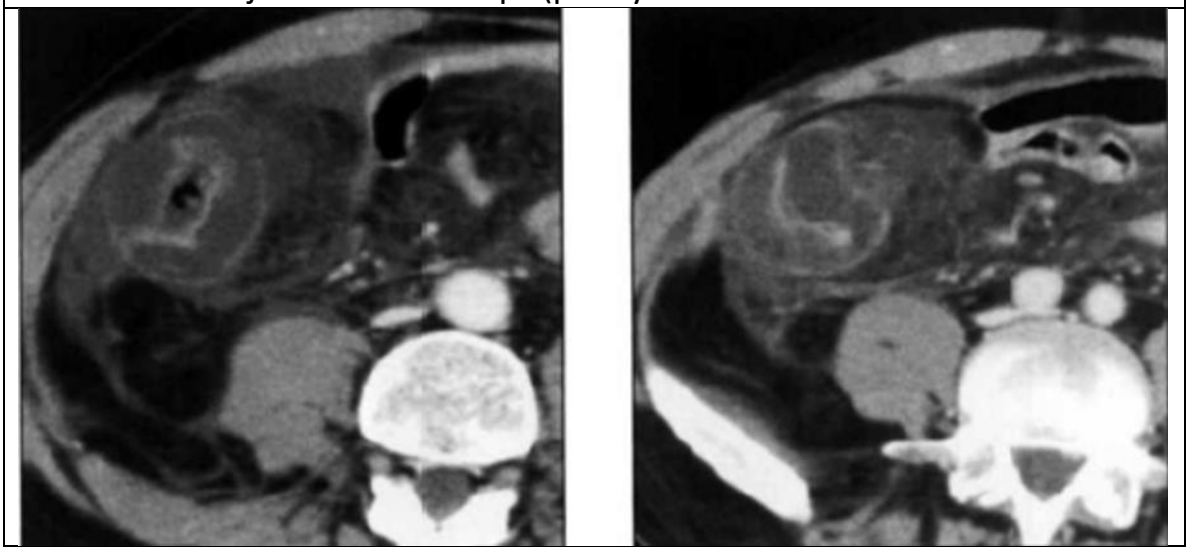
- Massive mural thickening of cecal ± ascending colon wall
- Fever, neutropenia & right lower quadrant
- Tenderness in immunosuppressed host
- Inflammatory or necrotizing process
- Usually seen in severely neutropenic patients
- Post chemotherapy or bone marrow transplant

Distribution:

- Cecum ± ascending colon + distal ileum

Imaging findings:

- Circumferential wall thickening of
- Decreased bowel-wall attenuation (due to edema)
- Pericecal fat stranding + thickened fascial planes
- Pericolonic fluid collection
- ± Pneumatosis, pneumoperitoneum
- ± Dilated adjacent bowel loops (paralytic ileus



6) Radiation Enteritis

- A bowel pathology resulting from toxic effects of radiotherapy on the bowel wall and vasculature.

Clinical presentation

- The clinical presentation is nonspecific with abdominal pain, vomiting, bloody diarrhoea and steatorrhoea.
- Patients with chronic radiation enteritis may develop deficiencies of calcium, iron and vitamin B12 deficiency

Classification:

- Acute Stage : Concurrent Or Within 2 Months Of Treatment
- Subacute : 2 - 12 Months After Treatment
- Chronic : > 12 Months After Treatment

Fluoroscopic enteroclysis

Acute radiation enteritis

- Bowel loops appear spastic with luminal narrowing and oedma of mucosal folds

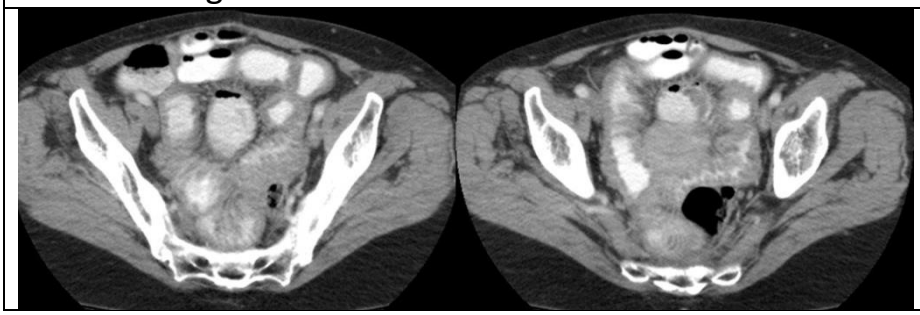
Chronic radiation enteritis

- Thickening of bowel wall and folds due to oedema or fibrosis
- "Stack of coins appearance" enlarged smooth, parallel mucosal folds
- Single or multiple bowel stenosis
- Ulcers

CT and MR findings

- Bowel wall thickening and luminal narrowing
- Small bowel obstruction
- Fistulas between the bowel (especially colon) and the bladder or vagina

- Following pelvic radiotherapy, enteritis of the small bowel typically involves the more fixed terminal ileum and manifests as bowel wall thickening and submucosal edema at CT



II- Infectious Enterocolitis

- Gastroenteritis and colitis are probably the most common causes of bowel wall thickening and are usually diagnosed clinically.

Causative organism:

- Bacterial: E.coli, Shigella, Salmonella, Yersinia, Campylobacter and Staphylococcus.
- Viral: Rotavirus, Herpes, and Cytomegalovirus.
- TB
- Parasites
- Pseudomembranous Colitis.

Distribution:

- **Proximal small bowel**
  - Parasitic enteritis caused by Giardia and Strongyloides species
- **Distal small bowel**
  - Salmonella
  - Shigella
  - Yersinia
- **Distal ileum and cecum**
  - Tuberculosis
  - Typhlitis
  - Amebiasis
- **Right colon:**
  - Salmonella
  - Shigella
  - Campylobacter
  - Yersinia enterocolitica
- **Left colon and Rectosigmoid**:
  - Schistosomiasis
- **Rectosigmoid:**
  - HSV
  - Gonorrhea
- **Diffuse colitis**
  - E.Coli
  - CMV
  - Cryptococcus

1) E. Coli Infection

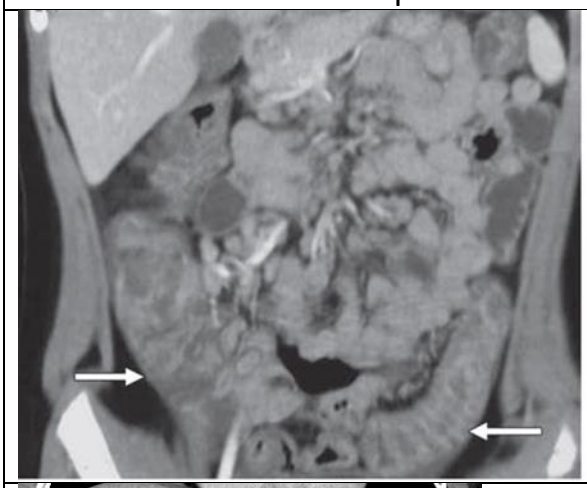
- E coli infection in children may result in hemolytic uremic syndrome.
- This syndrome is triggered by an infection that induces an autoimmune response characterized by a microangiopathic hemolytic anemia, thrombocytopenia, and renal failure.
- Age: infants and young children
- is the most common cause of acute renal failure in children.

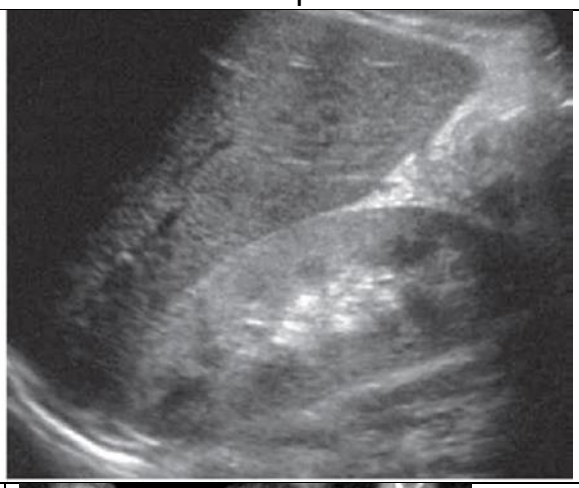
Distribution:

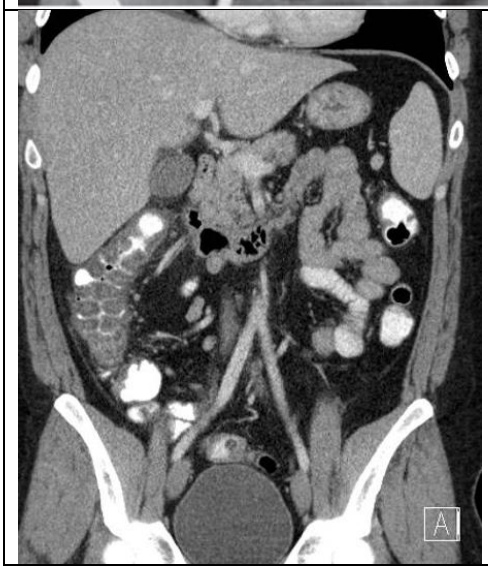
- ✓ ***Pancolitis: Ascending + Transverse + Descending***

CT findings:

- Colonic mural stratification, narrowing of the bowel lumen,
- Pericolonic fat stranding.
- Colonic ischemia and perforation are well-known complications.







2) Salmonella (Typhoid Fever)

- Salmonella species are gram-negative facultative intracellular anaerobes that can cause a broad spectrum of clinical manifestations
- Route of infection: ingestion of bacteria in contaminated food and water
- can spread from person to person via the fecal-oral route

Clinical manifestation:

- Gastroenteritis, enteric fever, Salmonella bacteremia,
- Localized infections to a convalescent lifetime carrier state

GIT manifestations:

- Symmetric and homogeneous thickening of the ileal wall
- Toxic megacolon is a known complication
- Enlarged mesenteric LNs

Splenic:

- Splenomegaly - Rapture spleen - Splenic abscess

GB:

- Acute acalculous cholecystitis: Gallbladder wall thickening, distention, and pericholecystic fluid
- Perforation and empyema of the gall bladder

Mesenteric and Peritoneal:

- Ascites, localized or generalized mesenteric stranding, thickening
- Mesenteric adenopathy

Genitourinary:

- Nonspecific - asymptomatic bacteriuria
- Pyelonephritis – Cystitis - Renal abscess

Cardiovascular:

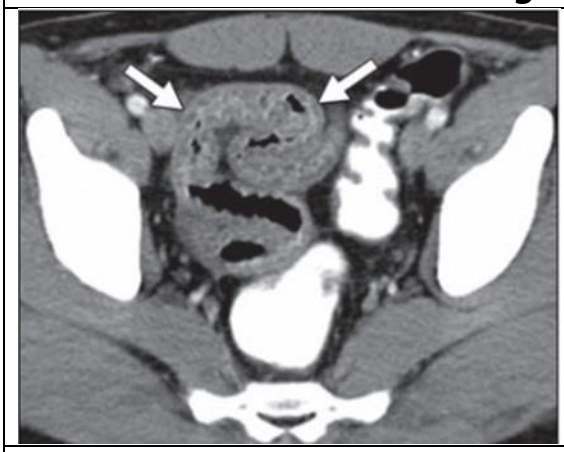
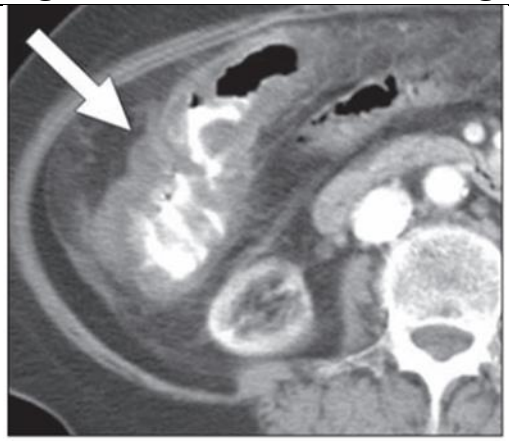
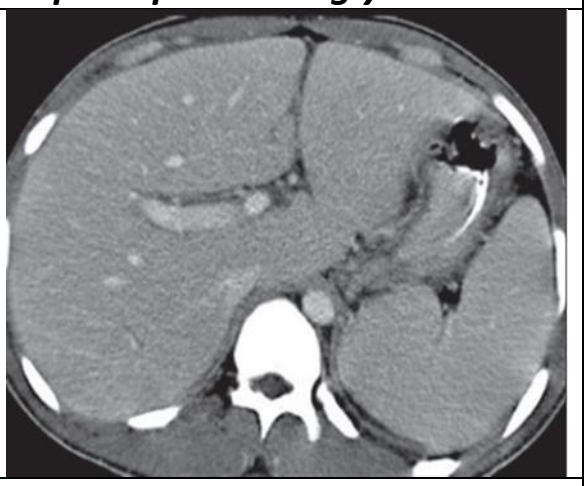
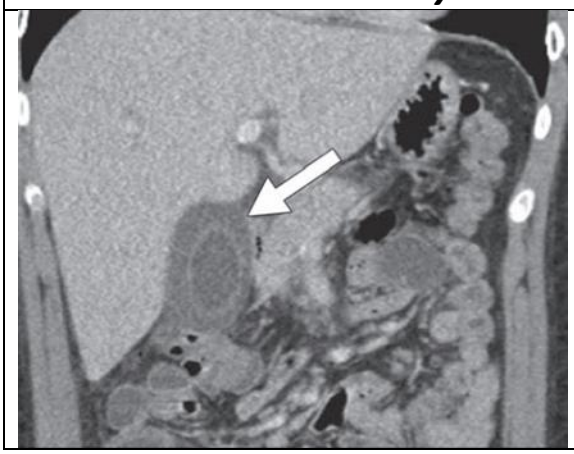
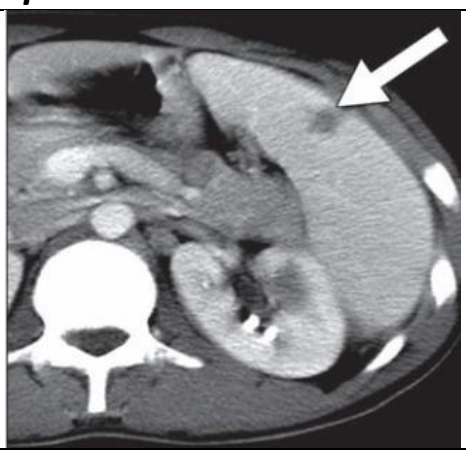
- Infective aneurysms: saccular aneurysm + periaortic gas collection
- Thrombophlebitis

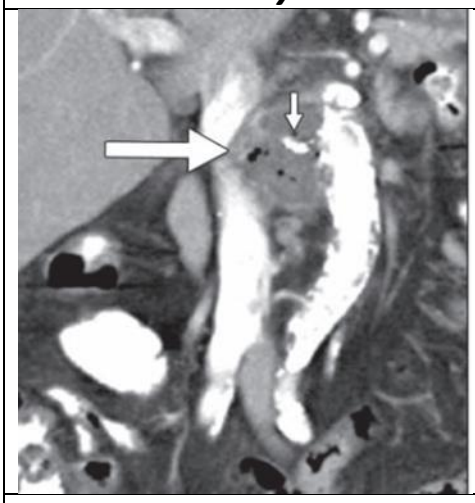
CNS:

- Meningitis – Encephalitis – hydrocephalus – Ventriculitis - Cerebral abscesses

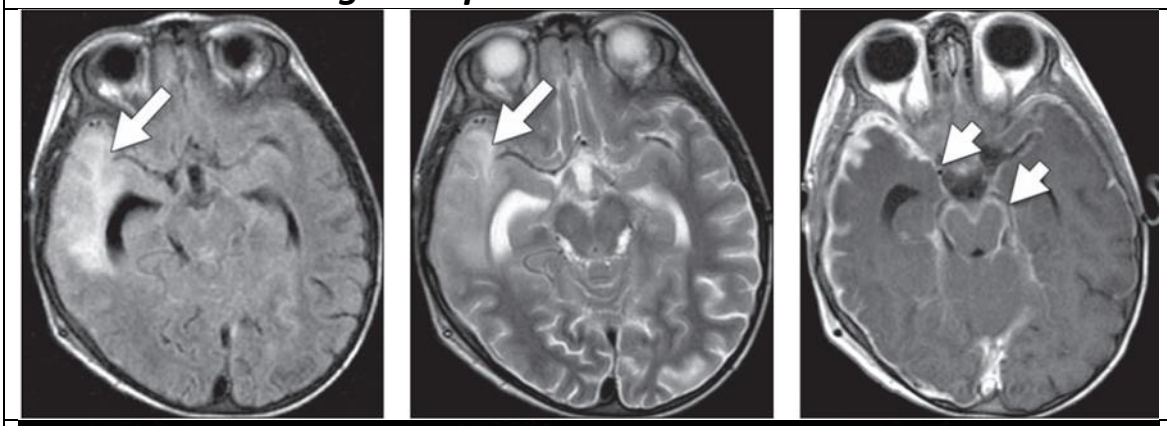
Musculoskeletal:

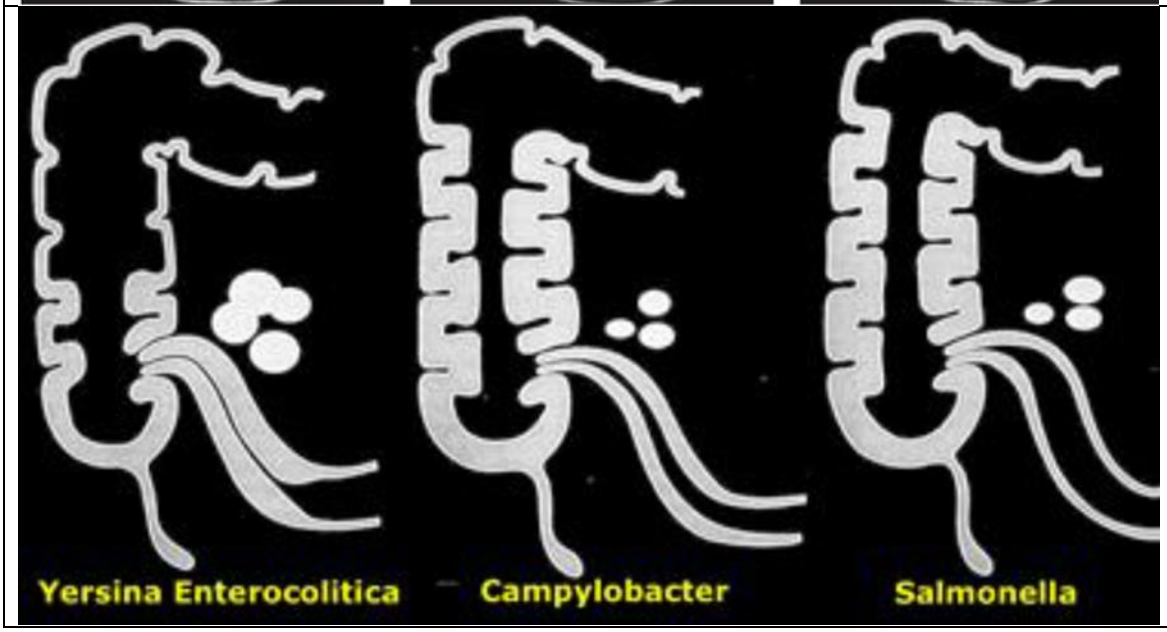
- The association between sickle cell disease and Salmonella osteomyelitis is well known
- Polymyositis, septic arthritis, periosteitis, and abscess formation.

Distal ileum mural thickening	***Right colon mural thckening***
	
Mesenteric lymphadenopathy	***Hepatosplenomeagly***
	
Acute aculacular cholecystitis	***Splenic small abscess***
	

Infected abdominal aortic saccular aneurysm	*Renal vein thrombosis*
	

Salmonella Meningoencephalitis





3) CMV

- Cytomegalovirus infection of the gastrointestinal tract is usually seen in patients who are severely immunocompromised, such as solid organ transplantation and is common in HIV / AIDS
- The most common gastrointestinal manifestation of AIDS

CMV oesophagitis

- Small well circumscribed ulcers are present, with the mucosa between them appearing normal.
- Larger (~2cm) superficial mid oesophageal ulcers are said to be relatively characteristic of CMV oesophagitis
- Deep ulceration is uncommon .

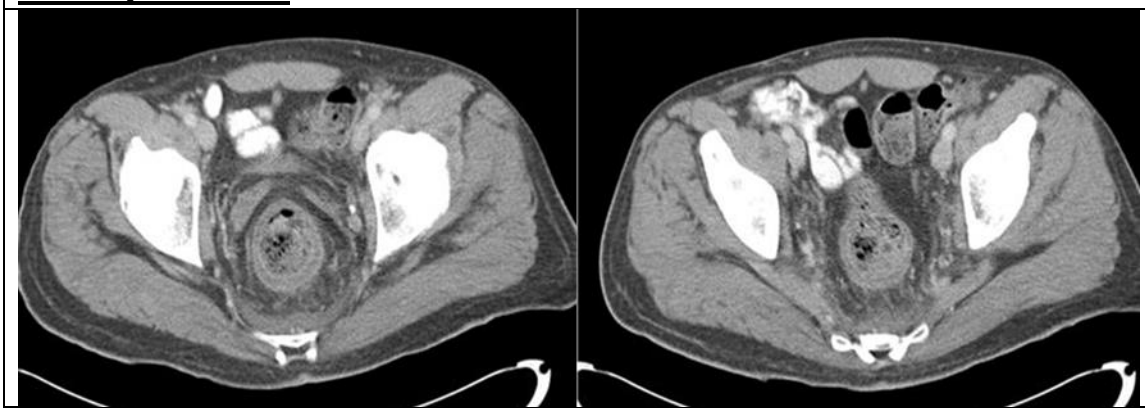
CMV gastritis

- Typically the antrum is involved, and it has a nodular mucosal pattern with luminal narrowing

CMV enterocolitis

- The appearances are similar to that of inflammatory bowel disease, with mural thickening and surrounding stranding, although often the thickening is patchy and not circumferential
- Ascites is seen in almost half of cases.
- Both diffuse and segmental involvement is encountered.
- Involvement of the small bowel is less frequent, seen in only 42% of cases .
- Lymph node enlargement is usually not present.
- Perforation has the usual imaging halmarks of free intraperitoneal fluid and gas

CMV proctitis



4) Abdominal Tuberculosis

- **Primary infection** is more commonly seen in AIDS patients (Myocobacterium avium-intracellulare) or by ingestion of infected milk (M. bovis).
- **Secondary infection** occurs after the tubercle bacilli are coughed into the mouth and swallowed or hematogenously spread from pulmonary TB. Chest radiographs are abnormal in approximately 50% of patients with intestinal TB.

- **Pulmonary TB: 85-90%**
- **Extra-pulmonary TB: 10-15%**
    - **Genitourinary**
    - **Gastrointestinal**
    - **MSK**
    - **CNS**

Abdominal TB:

a) **Gastrointestinal tract**
b) **Peritoneum and mesentery**
c) **Abdominal LNs**
d) **Solid organs**

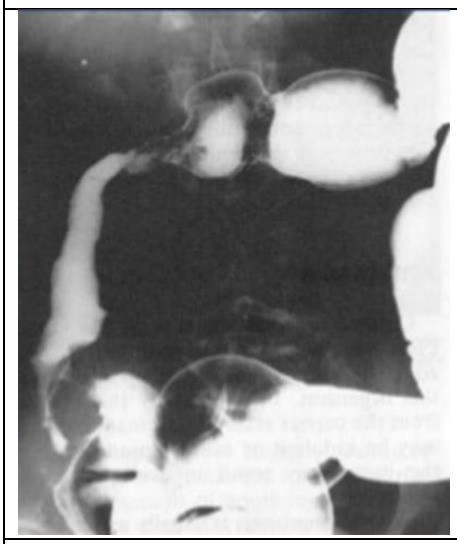
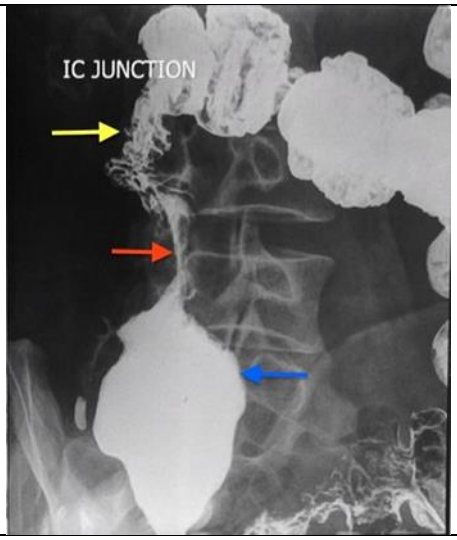
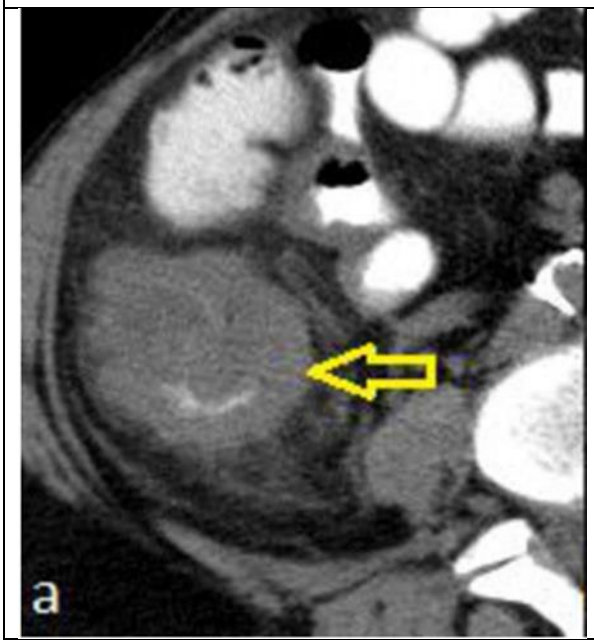
a) Intestinal TB => 3 Categories:

- **The ulcerative form** of TB is seen in approximately 60% of patients. Multiple superficial ulcers are largely confined to the epithelial surface.
- **The hypertrophic form** is seen in approximately 10% of patients and consists of thickening of the bowel wall with scarring; fibrosis; and a rigid, masslike appearance that mimics that of a carcinoma.
- **The ulcerohypertrophic form** is a subtype seen in 30% of patients. These patients have a combination of features of the ulcerative and hypertrophic forms.

Distribution:

- ***Right colon + Proximal transverse colon + Cecum + ileum + ileocecal valve***

Fleischner sign	String Sign
• Thickening of the valve lips and marked hypertrophy • Narrowing of the terminal ileum • Widely patent ileocecal valve • Right-angle intersection between ileum and cecum	• Persistent narrow stream of barium in the distal ileum • Short annular strictures
Pulled up Caecum	**Goose Neck Deformity**
• Caecum become conical and shrunken and retracted out of the iliac fossa due to contraction of the mesocolon	• Loss of the normal ileocecal angle • Dilated terminal ileum appears suspended and hanging from retracted shortened caecum.

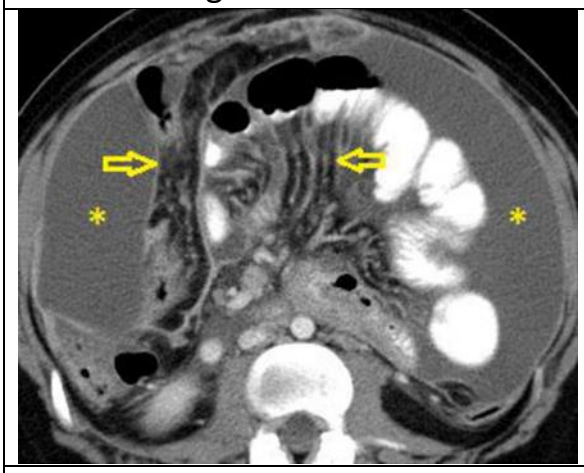
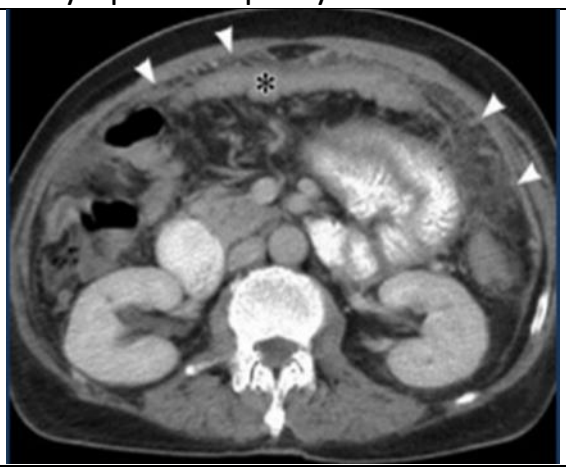
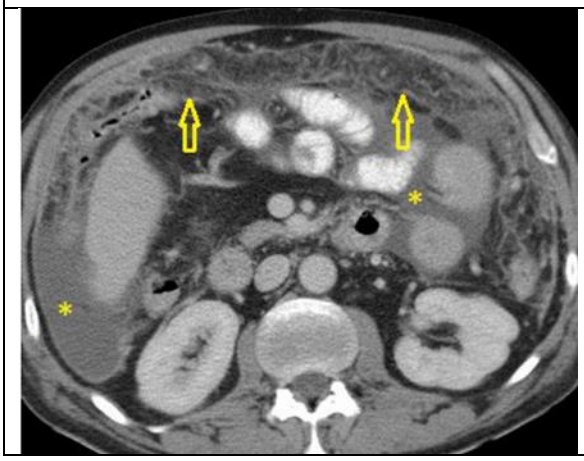
Stierlin's sign	
• Conical and shrunken caecum • Widely open ileocecal valve • Narrow terminal ileum • Rapid emptying of the diseased segment	• Yellow arrow indicates the shrunken caecum and pulled-up' away from RIF • Red arrow indicates stricturous narrowing of terminal ileum and ileocaecal junction • blue arrow indicates proximal ileal dilatation
	
○ ***Concentric mural thickening of the ascending colon and cecum***	○ ***Concentric mural thickening of the terminal ileum***
	

○ *Thickening of the ileocecal valve.*	○ *Thickening of the terminal ileum.*

DD: TB Versus Crohn's disease

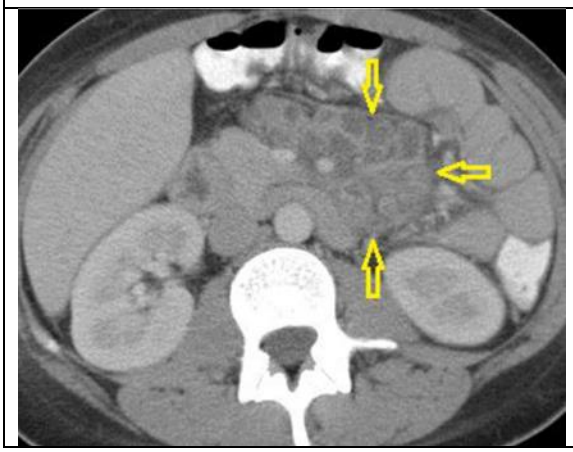
Tuberculosis	Crohn's disease
Asymmetric wall thickening, irregular	Circumferential bowel wall thickening
Fleischner sign on barium studies	Cobblestone appearance on barium
No creeping fat	Creeping fat (abnormal quantity of mesenteric fat)
Positive chest film (50%)	Negative chest film
Omental and peritoneal thickening	Normal omentum and peritoneum

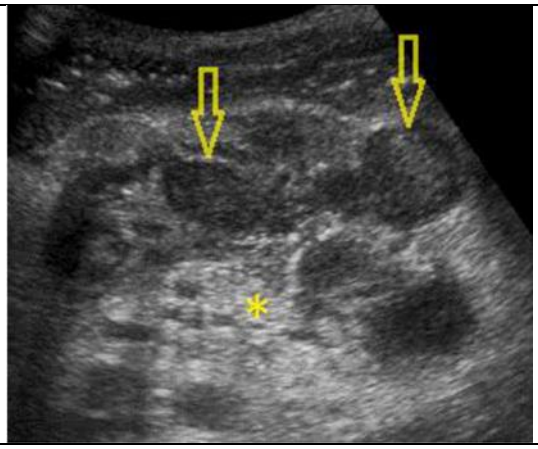
b) Peritoneal TB => 3 Types

Wet type	Dry type:
• Free or loculated • High density ascites is thought to be due to high protein and cellular content. • Peritoneal and mesenteric thickening and enhancement	• Thickened 'cake-like' omentum • Peritoneral and mesenteric thickening and enhancement • Fibrous adhesions • Caseous mesenteric lymphadenopathy
	
Fibrotic type	
• Omental 'cake-like' mass • Fixed bowel loops. • Matted loops and mesentery • Loculated ascites	
	

c) Tuberculous Lymphadenitis

- LN groups: Mesenteric, para-aortic, peri-portal and peri-pancreatic LNs
- Enlarged discrete or amalgamated LNs
- Central hypoechoic / hypodensity
- Rim enhancement



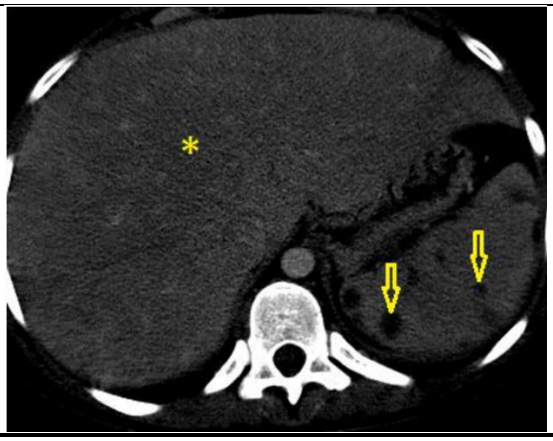


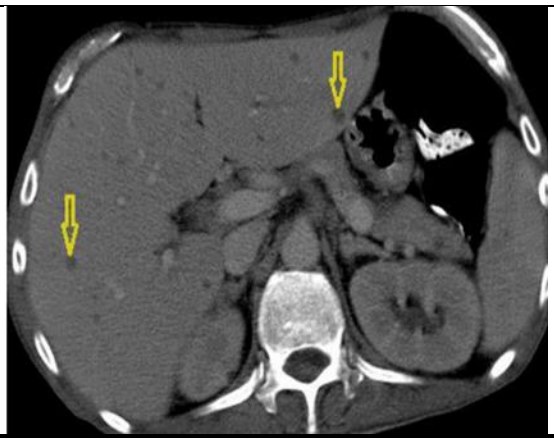
d) Visceral Tuberculosis

Hepatosplenic tuberculosis:

- Military – Micronodular pattern

Multiple small hypoenhancing nodules in the spleen (arrows).	Multiple small hypoenhancing focci in the liver parenchyma corresponding to small tuberculous abscesses

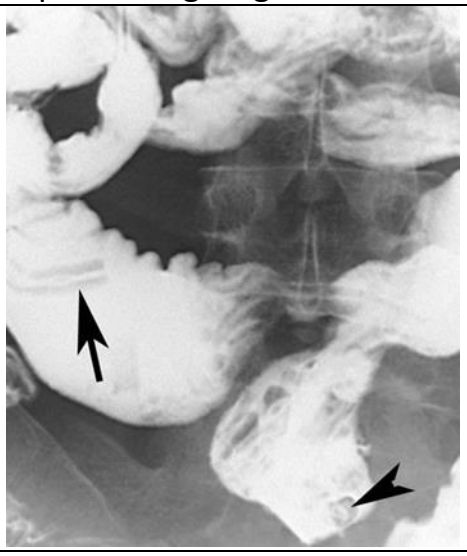




• Involvement of the ovaries and fallopian tubes • Hydrosalpinges (arrow). • A small amount of free peritoneal fluid in the pelvis	• Bilateral adrenal nodules with rim enhancement and central areas of necrosis.
• Spondylodiscitis involving T10-T11 intervertebral disc • D10 collapsed. • Paravertebral mass at this level, with extension into the spinal canal.	

5) Parasitic Intestinal Infection

- **Ascariasis:** Linear filling defects up to 3S cm in SB
- **Giardiasis**: thickened duodenal & jejunal folds
- **Amebiasis:** colon ulcerations

Ascaris as longitudinal filling defect in the distal small bowel	On transverse sections, the worm appears as a target sign (arrowhead) with body wall and a central dot representing its gut
	

6) Pseudomembranous Colitis

- Pseudomembranous colitis results from toxins produced by an overgrowth of Clostridium difficile, most often but not exclusively associated with antibiotic therapy; most commonly clindamycin.

Distribution:

- Usually entire colon (pancolitis)
- Rectum & sigmoid colon (80-90% of cases)

Imaging g findings:

- Colonic wall thickening & nodularity
- Thickening is more irregular & shaggy compared to symmetric & homogeneous in Crohn
- ***"Accordion sign":*** Represents trapped enteric contrast between thickened edematous colonic haustral folds
- Typically, no significant pericolonic fat stranding is seen.
- Relative paucity of pericolonic inflammation + marked colonic wall thickening differentiates PMC from other colitides
- Ascites in severe PMC

III- Bowel Ischemia

Causes of Acute Bowel Ischemia and/or Ischemic Colitis

Cause	Mechanism
Mesenteric arterial occlusion (proximal or distal)	Thrombosis, thromboembolism
	Atherosclerosis, dissection
	Cholesterol embolization
	Aortic surgery, stent placement, etc
	Therapeutic embolization for gastrointestinal hemorrhage
	Fibromuscular dysplasia (rare)
	Various types of vasculitides
	Thrombotic microangiopathies
	Small vessel diseases
Mesenteric venous occlusion (proximal or distal)	Venous thrombosis (primary and secondary)
	Phlebitis of intramural veins (rare)
Mechanical	Strangulation with or without mesenteric venous thrombosis
	Pronounced overdistention (prestenotic, distention colitis)
	Ischemic colitis due to endoscopy or enemas (rare)
Inflammation	Pancreatitis, appendicitis, diverticulitis, peritonitis, etc
Low flow or vasospasm	Hemorrhagic, cardiogenic, septic shock
	Cardiac failure, cardiac arrhythmia
	Nonpulsatile cardiopulmonary bypass
	Dehydration, stress (high-endurance athletes)
	Chronic renal failure requiring hemodialysis
	Use of various legal and "illegal" drugs
	Pheochromocytoma
	Familial dysautonomia (rare)
Other	Irradiation, trauma, corrosive injury
	Immunosuppression, chemotherapy
	Adjacent to intestinal tumors (focal)
	Carcinoids, carcinomas, leiomyomas, etc

1) Mesenteric Ischemia :

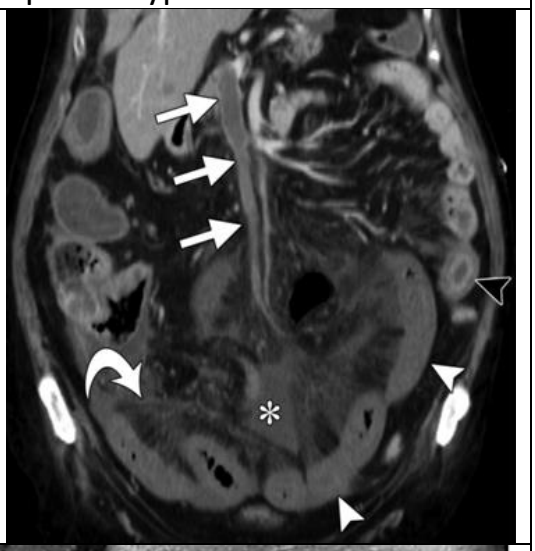
a) Arterial occlusion: (Most common cause):
   - SMA embolism associated with cardiovascular disease (Most common cause)
   - SMA thrombosis
   - Aortic dissection.

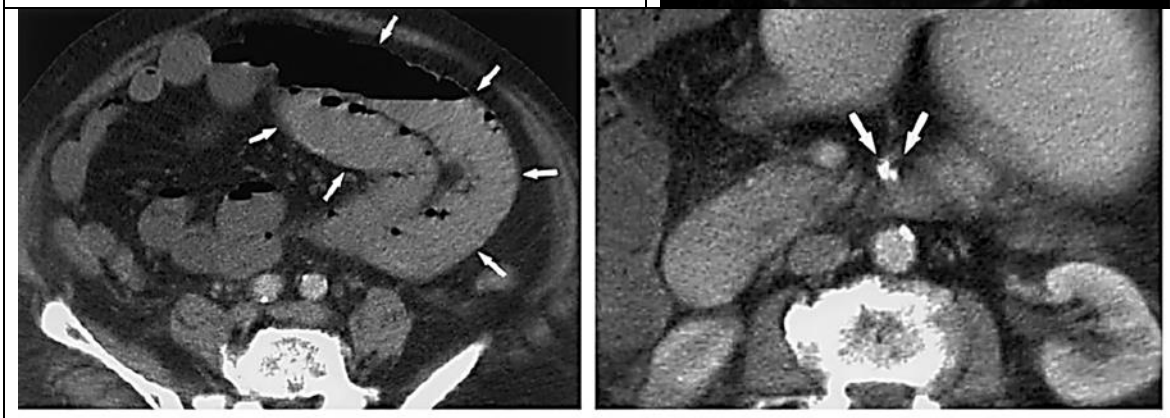
b) Venous occlusion

c) Low flow states such as poor cardiac output or hypovolemia

Imaging findings

- Mesenteric vascular occlusion
- Bowel wall thickening
- Bowel dilatation
- Intramural edema
- Intramural hemorrhage
- Abnormal wall enhancement
- Halo sign – target sign
- Pneuomatosis intestinalis
- Mesenteric fat edema
- Ascites.





a. b.

Figure 3. (a) Contrast-enhanced transverse CT scan shows several infarcted small-bowel loops (arrows), which manifest with dilatation and air-fluid levels but no wall thickening, due to transmural small-bowel necrosis. (b) Contrast-enhanced transverse CT scan shows large cholesterol embolus (arrows) in the superior mesenteric artery, confirmed at surgery, which caused acute mesenteric infarction.

2) Shock Bowel Syndrome

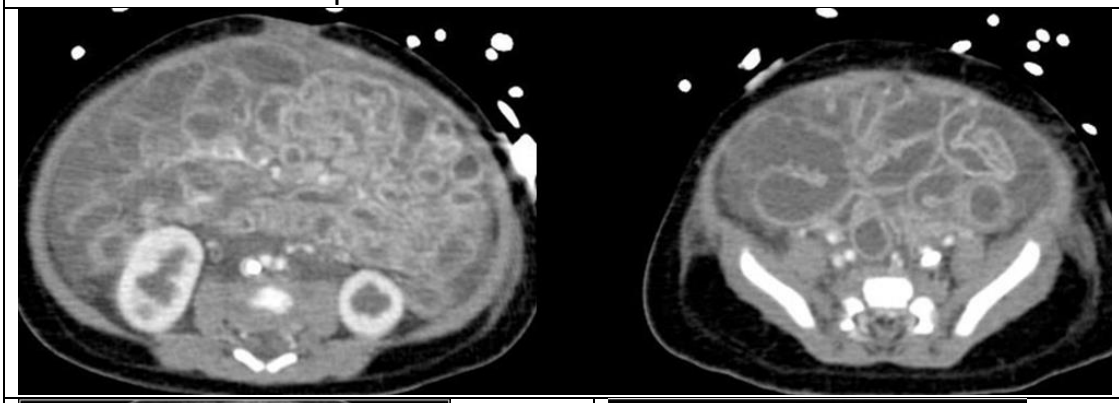
- Shock bowel refers to a radiographic feature which occurs in the context of profound hypotension +/ - hypovolaemia.
- It can occur in the context of many clinical settings inclusive of sepsis, blunt abdominal trauma, bacterial endocarditis, cardiac arrest, and diabetic ketoacidosis.

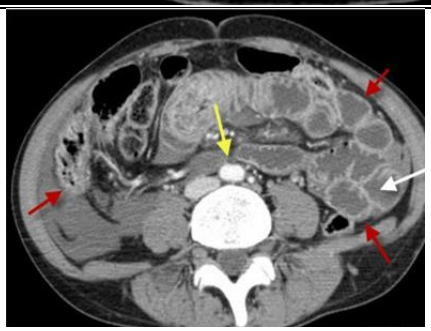
Associations

- Hypovolemia
- Trauma
- Sepsis
- Cardiac arrest
- Severe head injury

Imaging findings:

- Collapsed inferior vena cava
- Small calibre aorta
- Evidence of solid organ hypoperfusion
- Bowel wall enhancement + Thickening (Water target sign).
- Dilated bowel loops.





3) Vasculitis

- Systemic vasculitis affecting GIT is not common.
- Inflammation of the blood vessels of small intestine caused by a large group of rare, systemic conditions

- **Polyarteritis nodosa**: Small- to medium-vessel
- **Henoch-Schonlein purpura (HSP):** Small-vessel
- **Systemic lupus erythematosus (SLE):** Small-vessel
- **Behcet syndrome:** Small-vessel

Distribution:

- Long segment
- Multiple segments + skip areas.
- Non segmental distribution
- Segmental or extensive intestinal involvement

Imaging findings:

- Aphthous ulcers
- Straight, thickened folds ± dilatation of bowel lumen
- Concentric filling defects (submucosal hemorrhage)
- Ulceration and stricture (small-vessel)
- Submucosal edema and hemorrhage
- ± Thumbprinting; pneumatosis intestinalis

Complications:

- Paralytic ileus, ischemia, hemorrhage, perforation, stricture, fistula, peritonitis, sepsis
- Polyarteritis nodosa: Renal failure, congestive heart failure, myocardiac infarction, cirrhosis, hepatic carcinoma
- HSP: Intussusception in children, renal failure
- SLE: Renal failure

4) Inflammatory Condition:

Pancreatitis
Appendicitis
Diverticulitis
Peritonitis

5) Trauma

Penetrating trauma:

- Cause damage to major vessels: Ao / SMA / IMA
- Bowel perforation

Blunt trauma:

- Cause stricture

6) Instenial obstruction

Intestinal strangulation caused by:

- **Adhesions – Hernia – Volvulus – Intussusception**

Abnormal mesenteric vascular course:

Whirl sign
Convergence of mesenteric vessels towards one point
Reversed relation of mesenteric artery and vein.

7) Ischemic Colitis

Commonly watershed segments of colon

- Splenic flexure: Junction of SMA & IMA (Griffith point)
- Rectosigmoid: Junction of IMA & hypogastric artery (Sudeck point)
- Left-side colon: Typical in elderly with decreased perfusion
- Right-side: Young patients (decreased collateral blood supply); chronic renal failure

Radiography: Plain x-ray abdomen (supine view)

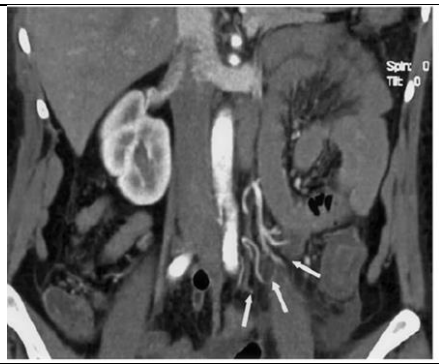
- Normal or nonspecific ileus
- Thumbprinting (submucosal edema or bleeding)
- Luminal narrowing or transverse ridging (spasm)

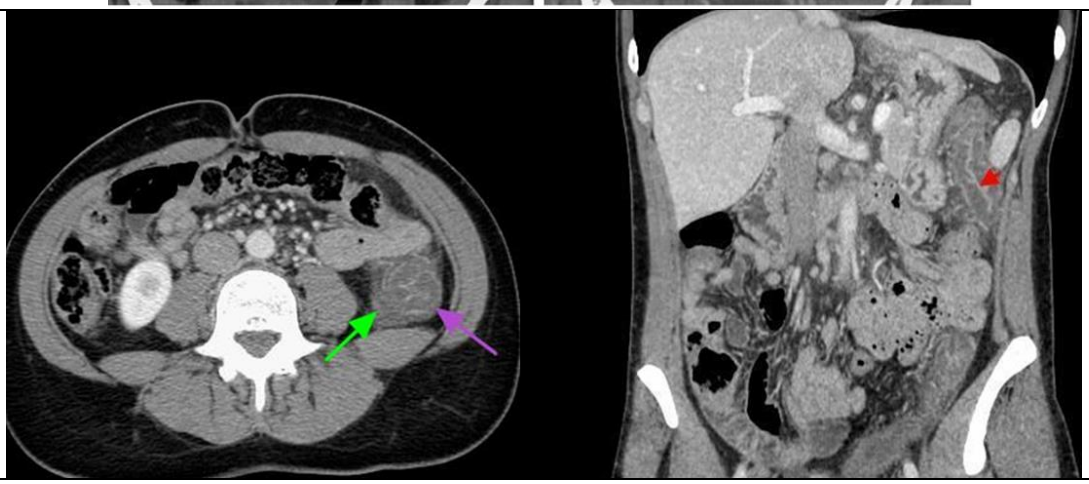
CT Imaging Findings:

- Bowel wall thickening (normal range 3-5 mm)
    - Circumferential, symmetric wall thickening ± thumbprinting
    - Due to submucosal edema or hemorrhage
- Bowel wall attenuation
    - Hypoattenuation: Submucosal or diffuse edema
    - Hyperattenuation: Submucosal or diffuse bleeding
    - Heterogeneous: Outer serosa & muscular layers
    - Double halo or target sign: Concentric layers of low & high attenuation
- ± Luminal narrowing or dilatation & air-fluid levels
- Loss of haustral pattern (rare); pericolic streakiness; paracolic fluid collections
- ± Pneumatosis intestinalis
    - Small gas bubbles within ischemic bowel wall
    - Circumferential or band like pneumatosis
- ± Porto-mesenteric venous gas
- Portal venous gas collects in periphery of liver

- ***Splenic flexure water shed area***
- ***Wall thickening + Luminal narrowing***
- ***Thumbprinting: due to submucosal edema or hemorrhage***

- ***Normal mesenteric vessels on CT angiography***
- ***Non-occlusive ischemic colitis***





Small Intestinal Tumors

A) SI Adenocarcinoma

- 25-40% of the SI Tumors.

Location:

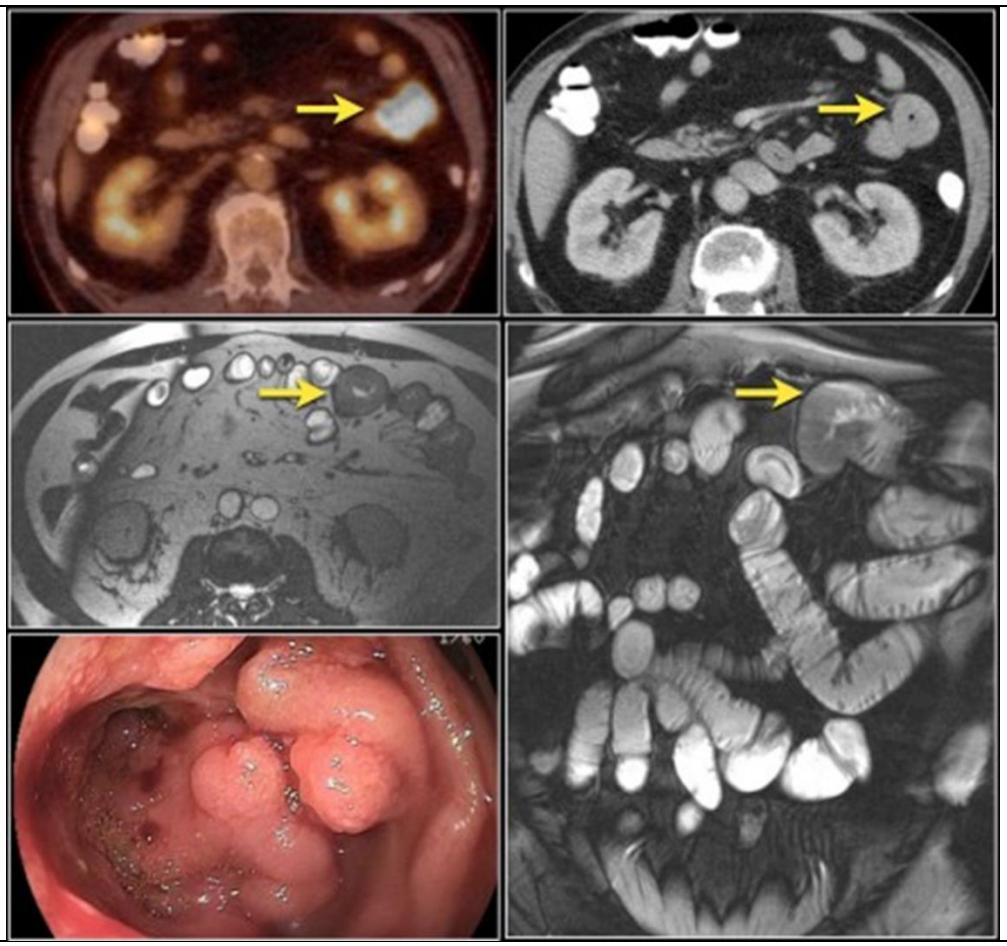
- Duodenum: 1st common location
- Jejunum: 2nd common location
- Ileum is often related to Crohn's disease as in this case.

Risk Factors:

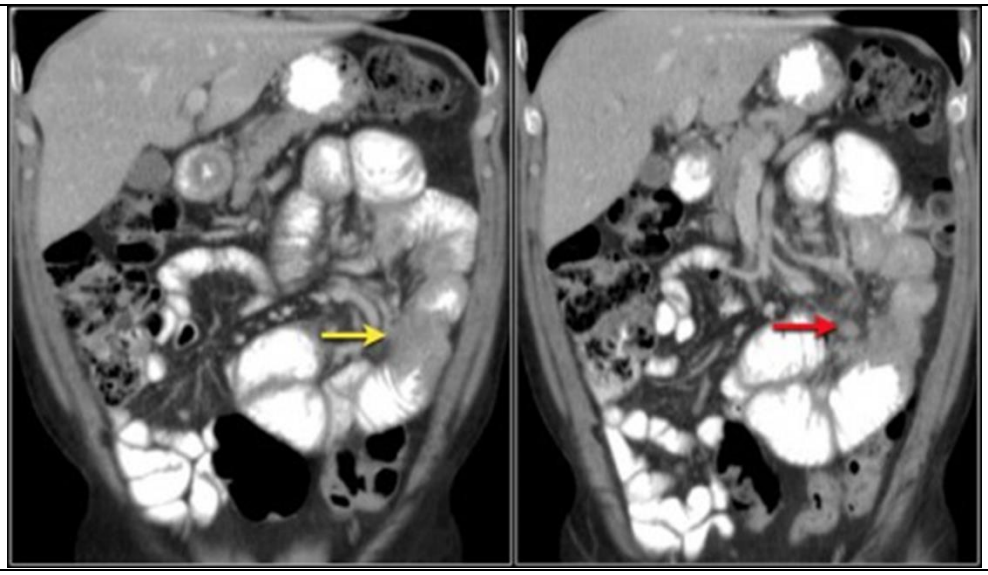
- Hereditary Nonpolyposis Colorectal Cancer (HNPCC)
- Familial Adenomatous Polyposis (FAP)
- Peutz-Jegher Syndrome
- Celiac Disease
- Crohn's Disease

Imaging features:

- Circumferential/Annular/Apple core mass with shouldering of the margins and obstruction.
- Intraluminal polypoid mass, which can lead to intussusception.
- Ulceration is a quite common feature.
- Extraluminal infiltration can present as fat stranding and mesenteric Invasion.
- Metastatic mesenteric LNs



Jejunal mass + Mesenteric LN



B) Mural = Subepithelial = Submucosal Tumors & Polyps

(See Gastric Chapter)

- **GIST (most common)**
- **Neuroendocrine tumors:**
  - **Typical carcinoid**
  - **Atypical carcinoid**
  - **Neuroendocrine Carcinoma**
- **Neurogenic tumors:**
  - **Schwannoma**
- **Smooth muscle tumors:**
  - **Rhabdomyoma**
  - **Rhabdomyosarcoma**
- **Vascular tumors:**
  - **Glomus**
  - **Hemangioma**
  - **Angiosarcoma**
  - **Kaposi sarcoma**
- **Lymphoma**
- **Metastasis**
- **Heterotopic Tissue**
- **Polyps**

Colorectal Tumors

A- Colorectal Carcinoma

- Most common cancer of the gastrointestinal tract

Clinical presentation

- Altered bowel habit or iron deficiency anaemia from chronic occult blood loss.
- Bowel obstruction, intussusception, heavy bleeding and metastatic disease may also be the initial manifestation

Risk factors

- Low fibre and high fat and animal protein diet
- Obesity (especially in men)
- Inflammatory bowel disease (IBD)
  - Chronic ulcerative colitis
  - Crohn disease
- Asbestos workers
- A family history of benign/malignant colorectal tumours
- History of endometrial/breast cancer
- Pelvic irradiation
- Ureterosigmoidostomy
- **Colonic adenoma (Adenoma-carcinoma sequence)**
- Dysplasia of colon within flat mucosa
- Prominent lymphoid follicular patter

Syndromes are seen in 6% of colorectal carcinomas.

- Familial adenomatous polyposis syndrome (FAP)
  - Gardner syndrome variant
  - Turcot syndrome variant
- Peutz-Jeghers syndrome
- Hereditary non-polyposis colon cancer syndrome (HNPCC)

Location:

- Recto-sigmoid: 55%
- Caecum and ascending colon: ~20%
- Ileocaecal valve: 2%
- Transverse colon: ~10%
- Descending colon: ~5%

Screening recommendations

- for persons >50 years of age: an annual faecal occult blood test and sigmoidoscopy/barium enema every 3 to 5 years
- for first-degree relatives of patients with colon cancer: screening should start at age 40

Dukes (Astler-Coller modification)

stage A: confined to mucosa
stage B: through muscularis propria
stage C: local lymph node involvement
stage D: distant metastases

TNM staging

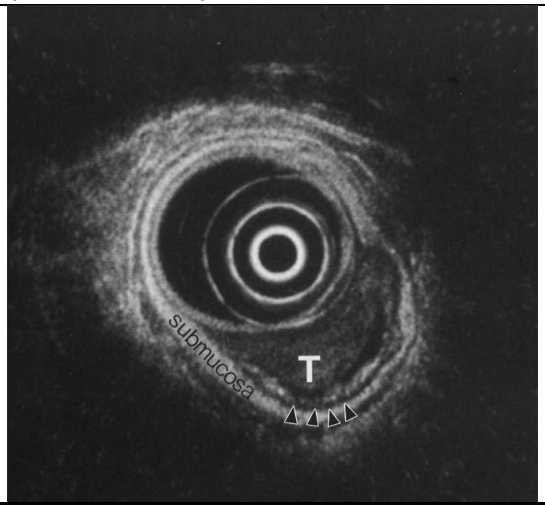
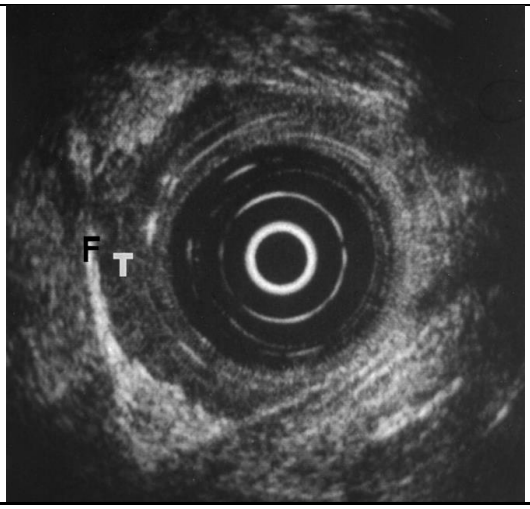
Primary tumour staging (T)
Tx: primary tumour cannot be assessed
T0: no evidence of primary tumour
Tis: carcinoma in situ
T1: into (but not through) submucosa
T2: into (but not through) muscularis propria
T3
    through muscularis propria into subserosa, or
    into non-peritonealised pericolic/perirectal tissues
T4a: penetration of the visceral peritoneal layer
T4b: penetration or adhesion to adjacent organs

Nodal status (N)
Nx: nodes cannot be assessed
N0: no evidence of nodal involvement
N1a: involvement of one regional nodes
N1b: involvement of 2-3 regional nodes
N1c: deposits involving serosa or non-peritonealised pericolic/perirectal tissues without regional nodal metastasis
N2a: involvement of 4-6 nodes
N2b: involvement of ≥7 mode

Metastases (M)
Mx: presence of metastases cannot be assessed
M0: no evidence of metastases
M1a: distant metastases confined to one organ
M1b: distant metastases to more than one organ or to peritoneum

❖Endoscopic sonography

- shows the layers of the bowel wall and usually allows differentiation between the submucosa and the muscularis propriaand between the muscularis propria and the surrounding fat
- Provides an opportunity to determine the depth of tumor penetration with an overall accuracy of 80–85%

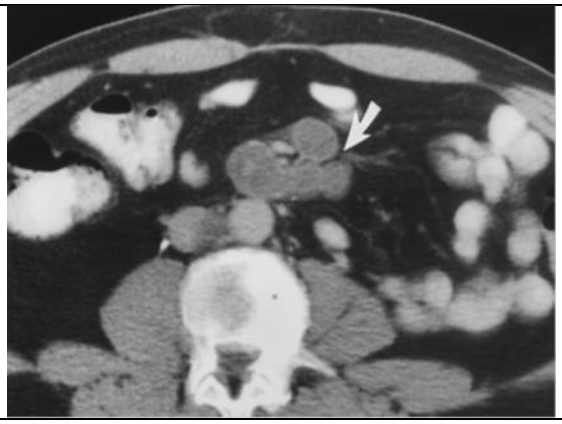
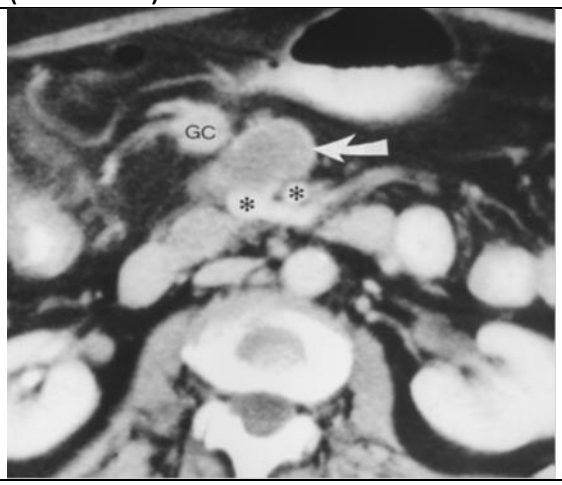
Tumor does not penetrate hypoechoic muscularis mucosa (arrowheads) or submucosa.	Tumor penetrates through all layers to hyperechoic perirectal fat (F).
	

❖CT

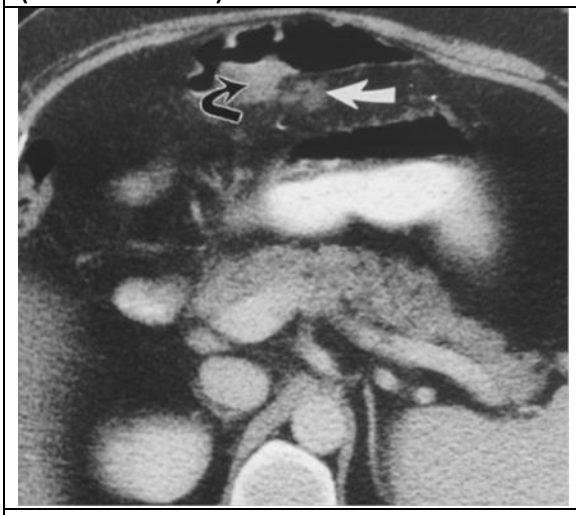
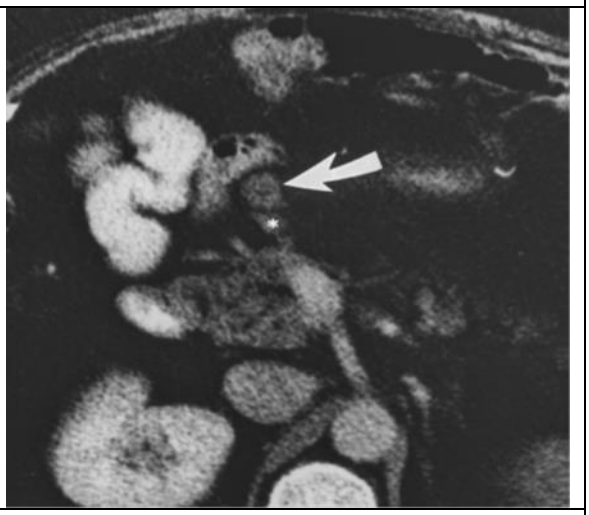
- Adequate luminal distention is essential for imaging and may be achieved with water as a negative contrast agent
- Detect tumor and adjacent spread,
- Sensitivity for local invasion ranges from approximately 50% to 70%.

❖ The nodal pathways of spread for colon cancer

- Carcinomas of the right colon => follow along the marginal vessels of the cecum and ascending colon => then along the ileocolic vessels => the root of the superior mesenteric artery

Mass in cecum (black arrow) Adjacent lymphadenopathy (white arrow).	Lymphadenopathy (arrow) followed to root of mesentery
	
Mass (M) at hepatic flexure Lymphadenopathy (arrow) anterior to superior mesenteric vessels (asterisks).	Lymphadenopathy (arrow) followed along gastrocolic trunk (GC) anterior to superior mesenteric vessels (asterisks).
	

- Tumors of the proximal transverse colon => spread along the marginal vessels on the mesocolic side of the colon => drain to the right or middle colic vessels => to the root of the mesocolon, anterior to the head of the pancreas.

Transverse colon mass (black arrow) with adjacent lymphadenopathy (white arrow).	Lymphadenopathy (arrow) followed along middle colic vessels (asterisk) in transverse mesocolon.
	

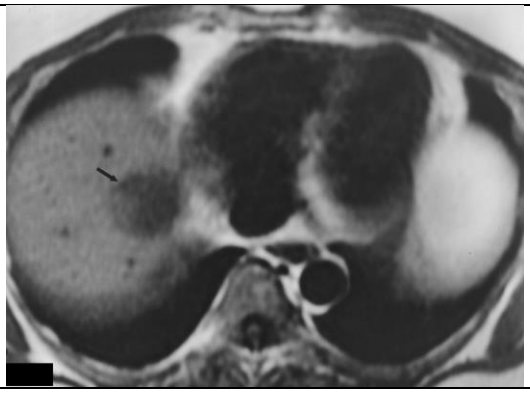
- Distal transverse colon and splenic flexure => follow the left middle colic vessels => inferior mesenteric vein just caudal to the body and tail of the pancreas.
- Cancers of the descending colon and sigmoid colon => spread to nodes along the left ascending colic and sigmoidal vessels => followed to the origin of the inferior mesenteric artery

Sigmoid colon cancer. shows extension of tumor into pericolonic fat (arrowheads) and adjacent nodes (arrow).	

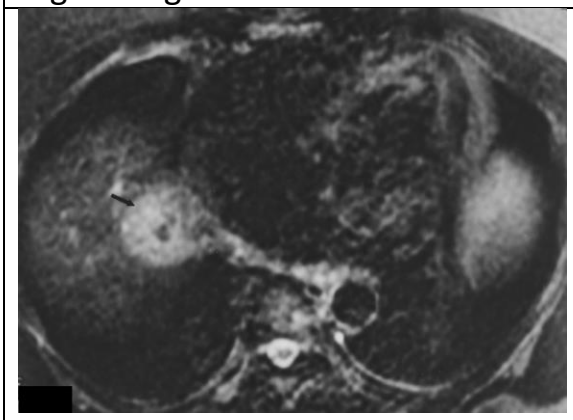
❖ Hepatic Metastasis

Calcified liver metastases (arrow) and calcification (arrowheads) in primary tumor in descending colon.

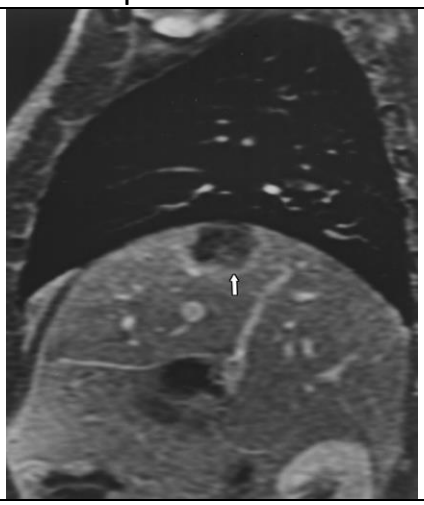
Low T1 signal



High T2 signal



+C: Peripheral enhancement

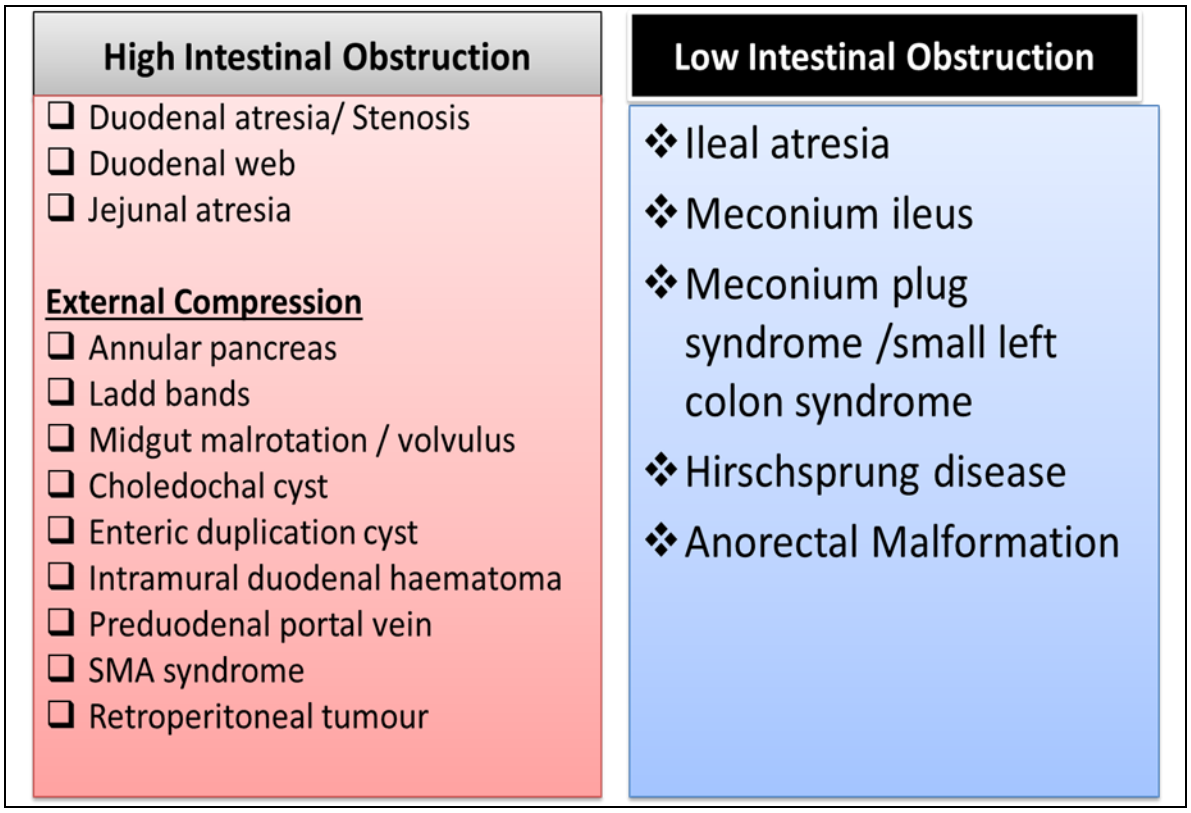


B) Mural = Subepithelial = Submucosal Tumors & Polyps

(See Gastric Chapter)

- **GIST (most common)**
- **Neuroendocrine tumors:**
  - **Typical carcinoid**
  - **Atypical carcinoid**
  - **Neuroendocrine Carcinoma**
- **Neurogenic tumors:**
  - **Schwannoma**
- **Smooth muscle tumors:**
  - **Rhabdomyoma**
  - **Rhabdomyosarcoma**
- **Vascular tumors:**
  - **Glomus**
  - **Hemangioma**
  - **Angiosarcoma**
  - **Kaposi sarcoma**
- **Lymphoma**
- **Metastasis**
- **Heterotopic Tissue**
- **Polyps**

Neonatal intestinal Obstruction



1) Duodenal Atresia

- Congenital malformation of the duodenum
- One of the commonest causes of a fetal bowel obstruction.
- Failure of canalization of duodenum

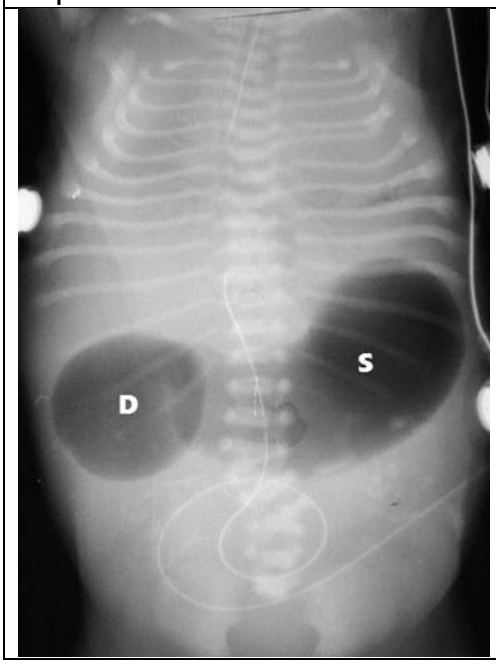
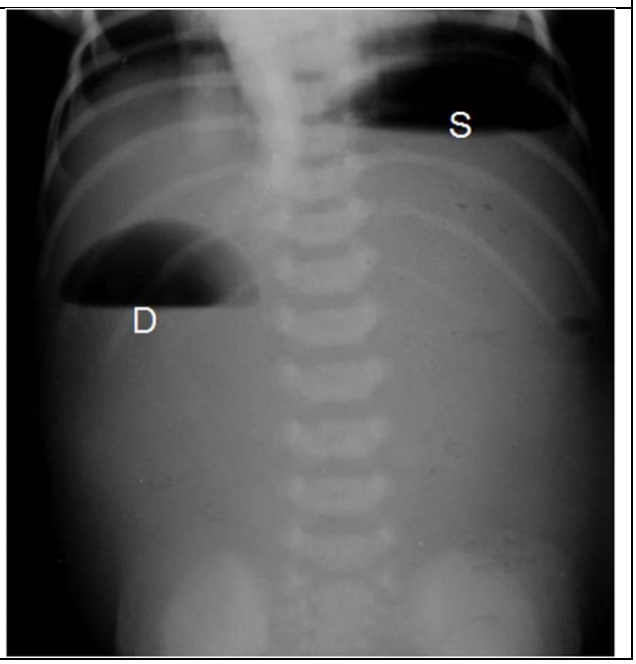
Associated conditions are common and include:

- Down syndrome:
  - ~30% of duodenal atresia cases may have Down syndrome
  - ~3% of Down syndrome cases may have duodenal atresia
- VACTERL association

Clinical Presentation:

- Abdominal distension, vomiting and absent bowel movements.
- If the atresia distal to the ampulla of Vater => Bilious vomiting.
- If the atresia proximal to the ampulla of Vater => non-bilious vomiting.

Double bubble sign = Dilatation of the proximal duodenum and stomach + No gas in the bowel distal to the dilated duodenum.

Supine	Erect
	

2) Duodenal web

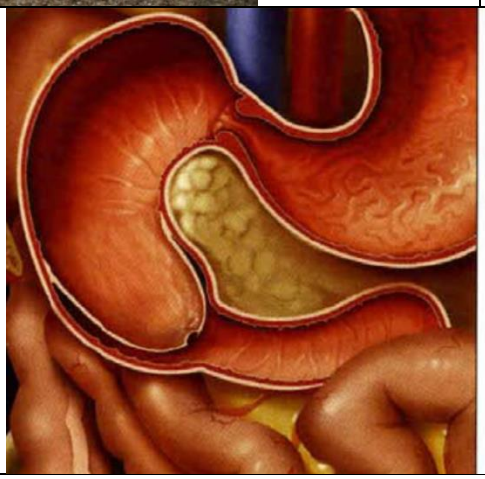
- A duodenal web, diaphragm or intraluminal diverticulum refers to a complete or incomplete obstruction at the duodenum due to a membranous web or intraluminal diverticulum.
- There is usually a small aperture at the centre differentiating this from a duodenal atresia.
- Location: 2nd part of the duodenum

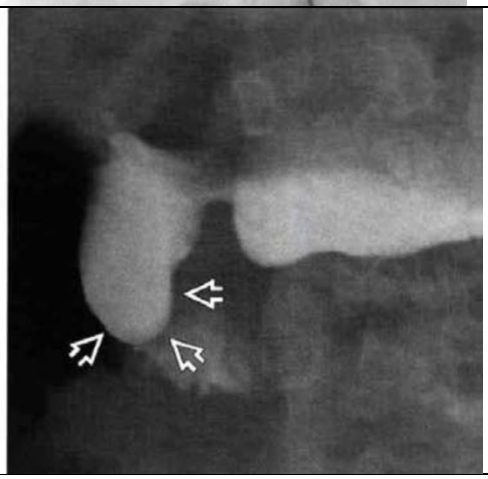
Plain radiograph

If severely obstructive may show a double bubble sign

Fluoroscopy

- "windsock sign" an intraduodenal barium-contrast filled sac that is surrounded by a narrow lucent line (web or intraluminal mucosal diaphragm) which is well demonstrated as the barium in the duodenum passes distal to the diverticulum.





3) Annular Pancreas

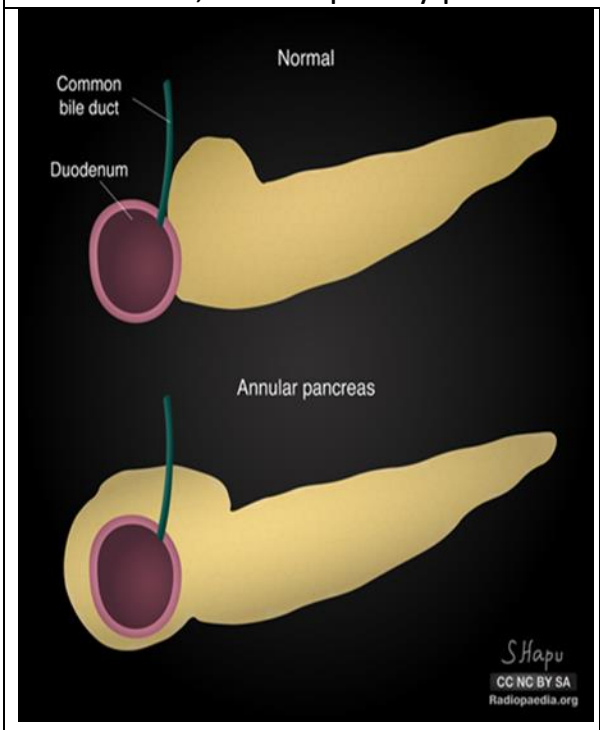
- is a morphological anomaly which can cause duodenal obstruction.
- due to failure of ventral bud to rotate with duodenum, causing encasement of duodenum.

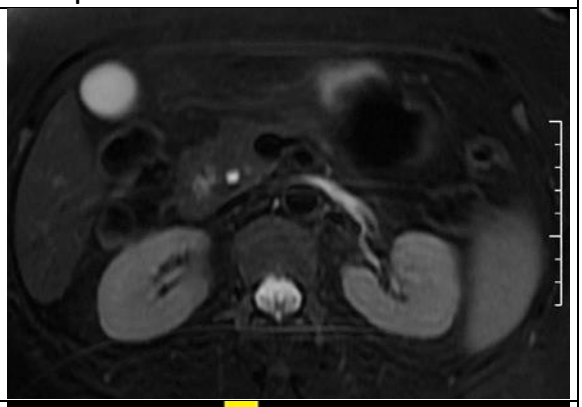
Classification:

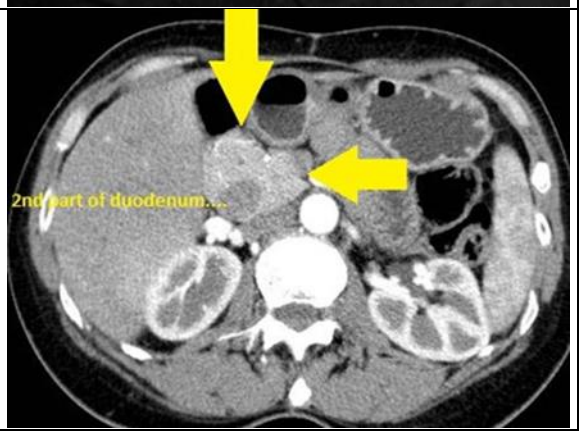
- **Complete annular pancreas:** pancreatic parenchyma or annular duct is seen completely surround the 2nd part of duodenum
- **Incomplete annular pancreas:** annulus does not surround the duodenum completely, giving a 'crocodile jaw' appearance

Imaging findings:

- Pancreatic tissue is seen to completely or incompletely surround the 2nd part of duodenum
- Associated duodenal narrowing and dilatation of proximal duodenum.
- In adults, it is frequently presented with pancreatitis.





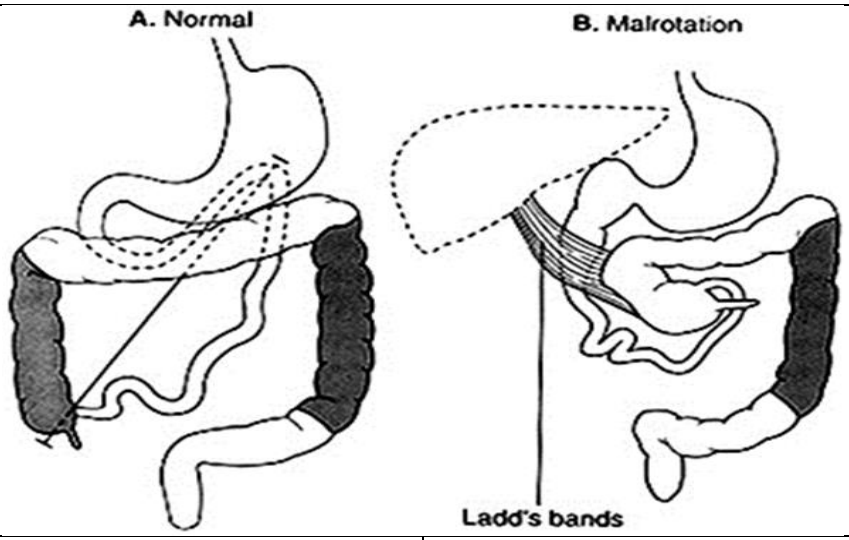


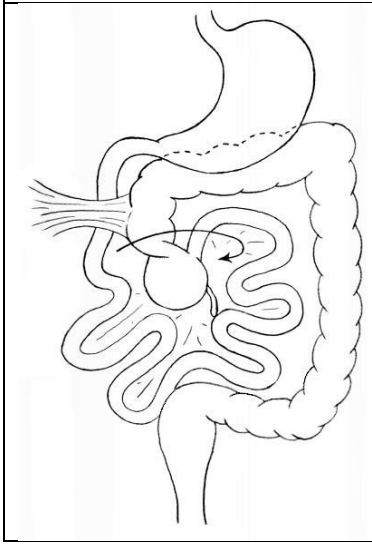
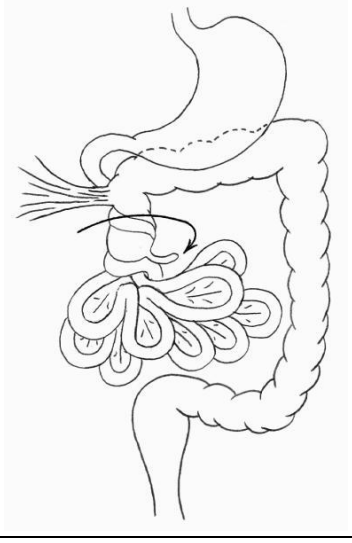
4) Ladd bands

- is the most commonly encountered form of peritoneal bands in disarrangement of intestines, e.g. intestinal malrotation.
- It extend from the abnormally positioned caecum to peritoneum and liver, crossing the duodenum in their course

Predisposing to:

- Duodenal obstruction
- Midgut volvulus
- Cecal volvulus



Midgut volvulus	Cecal volvulus
	

5) SMA Syndrome

- Rare vascular compression disorder
- Acute angulation of superior mesenteric artery (SMA) results in compression of the third part of the duodenum leading to obstruction.

- It should not be confused with nutcracker syndrome (which can be an association), also a superior mesenteric artery compression disorder, where the SMA compresses the left renal vein.

Etiologies

- Prolonged bed rest in supine position (body cast, whole-body burns, surgery)
- Substantial and, frequently, rapid weight loss
- Anorexia nervosa or malnutrition
- Loss of abdominal muscle tone (as in pregnancy)
- May be congenital
- Seen in those with asthenic build
- Exaggerated lumbar lordosis

Plain radiograph

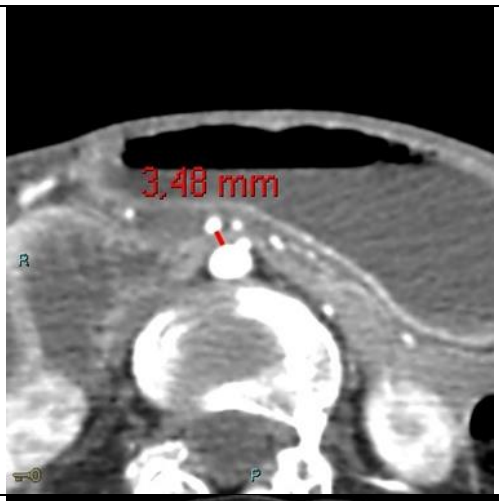
- Dilated, fluid and gas-filled stomach and proximal duodenum

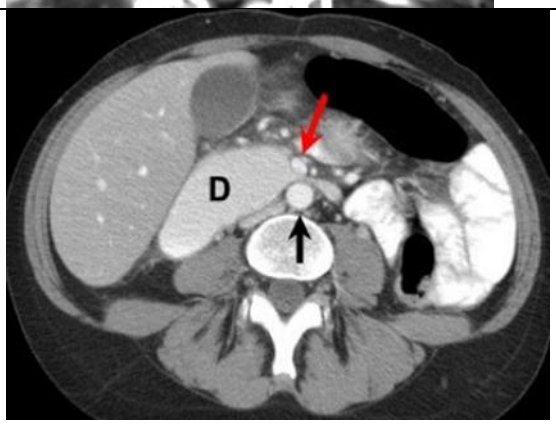
Upper GI fluoroscopy

- Dilatation of the first and second part of the duodenum
- Extrinsic compression of the third part
- Collapsed small bowel distal to the crossing of the SMA.

CTA /MRA

- Normally:
    - Aorto-mesenteric angle = 25-60°
    - Aorto-mesenteric distance = 10-28 mm
- SMA syndrome:
    - Aorto-mesenteric angle = 6° to 15°
    - Aorto-mesenteric distance = 2 to 8 mm


3,48 mm


D

6) Enteric Duplication Cyst

- Gastrointestinal duplication cyst is a rare congenital anomaly that may occur anywhere along the mesenteric side of the gastrointestinal tract.
- Duplication cyst is most common in the distal ileum, followed by the esophagus, colon, jejunum, stomach, and duodenum.
- It usually is attached to the gastrointestinal tract, has smooth muscle in its wall, and is lined with gastrointestinal epithelium.

2 types:

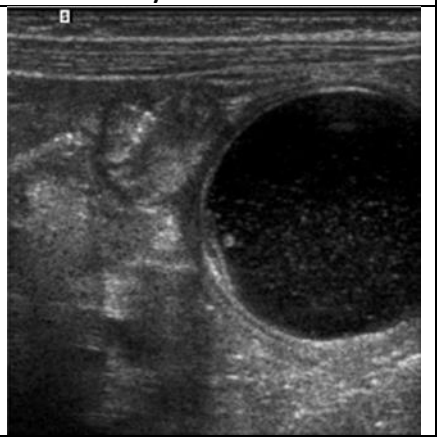
- Cystic duplication (80% of cases): no communication with the bowel lumen.
- Tubular duplication (20% of cases): communicates directly with the bowel lumen

Complications:

- Complications are rare
- Intestinal obstruction by volvulus or intussusception, bleeding, infection, and perforation.
- Gastrointestinal bleeding may occur as a result of peptic ulcers in the presence of heterotopic gastric mucosa.
- Malignant changes from duplication cysts are extremely rare

Imaging findings:

- US: “double-wall” sign: An echogenic inner mucosa surrounded by a hypoechoic outer muscular layer
- Fluid-filled cystic mass
- Thick, slightly enhancing wall
- An area of high attenuation within the cyst may be seen, a finding due to hemorrhage or proteinaceous material



7) Midgut Malrotation

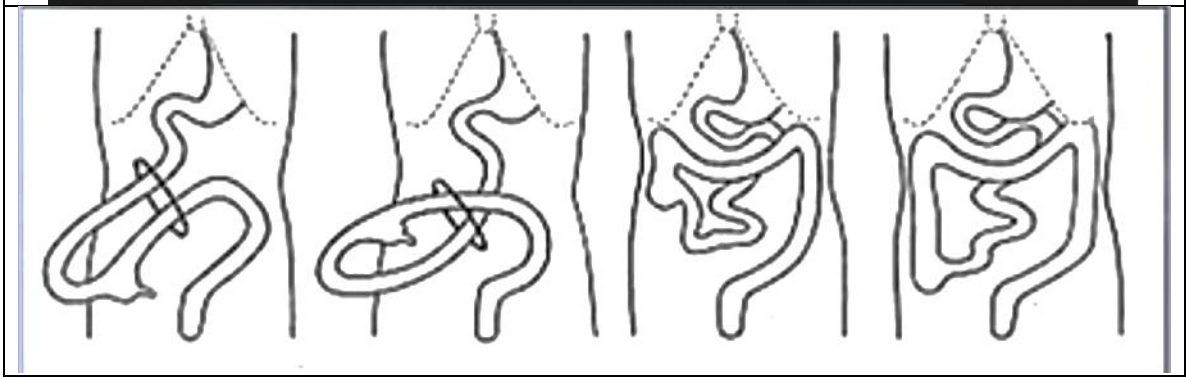
❖ **Normal Intestinal Rotation**

Rotation/fixation GI Tract: 6th week

- ✓ Insufficient room in abdomen for rapidly growing midgut
- ✓ 90 degrees counterclockwise rotation around SMA axis within UC
- ✓ Cranial limb to right; caudal limb to left

Rotation/fixation GI Tract: 10th week

- ✓ Intestines return to abdomen (reduction of midgut hernia)
- ✓ Cecum returns last
- ✓ Undergoes further counterclockwise rotation 180 degrees
- ✓ Total rotation 270 degrees



- Midgut malrotation is a congenital anatomical anomaly which results from an abnormal rotation of the gut as it returns to the abdominal cavity during embryogenesis
- Predispose to midgut volvulus and internal hernias

❖ **Criteria for Normal Dudeno-Jejunal Junction (DJJ):**

AP supine:

- DJJ is to the left of the spine
- DJJ is at the same level or more superior than duodenal bulb.

Lateral view:

- Duodenum typically courses posterior then inferiorly

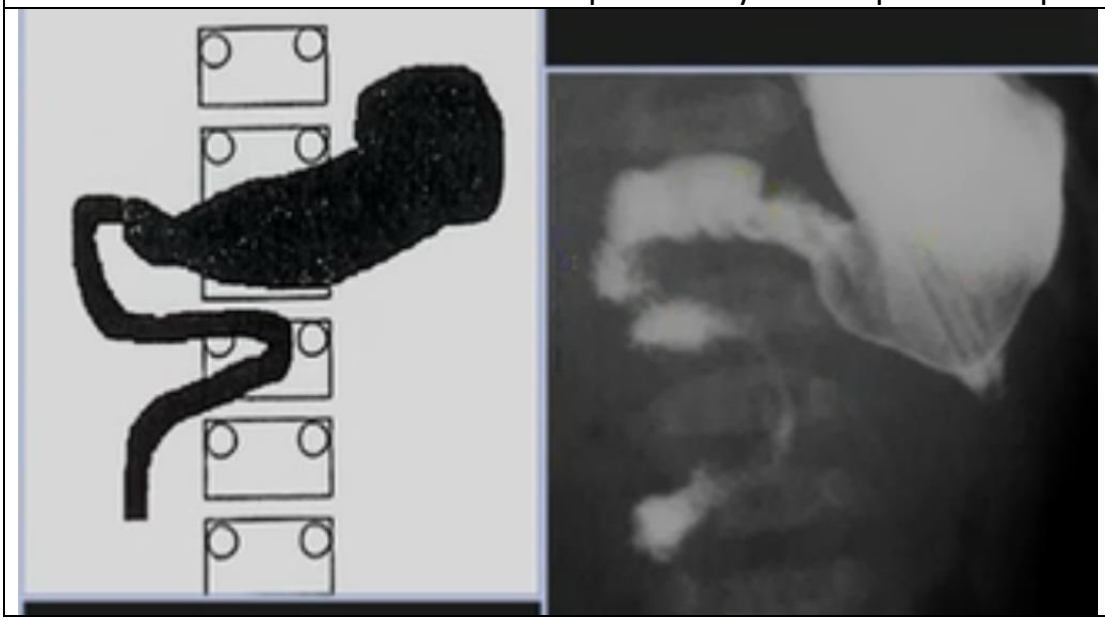
❖ **Abnormal duodeno-jejunal junction (DJJ) location:**

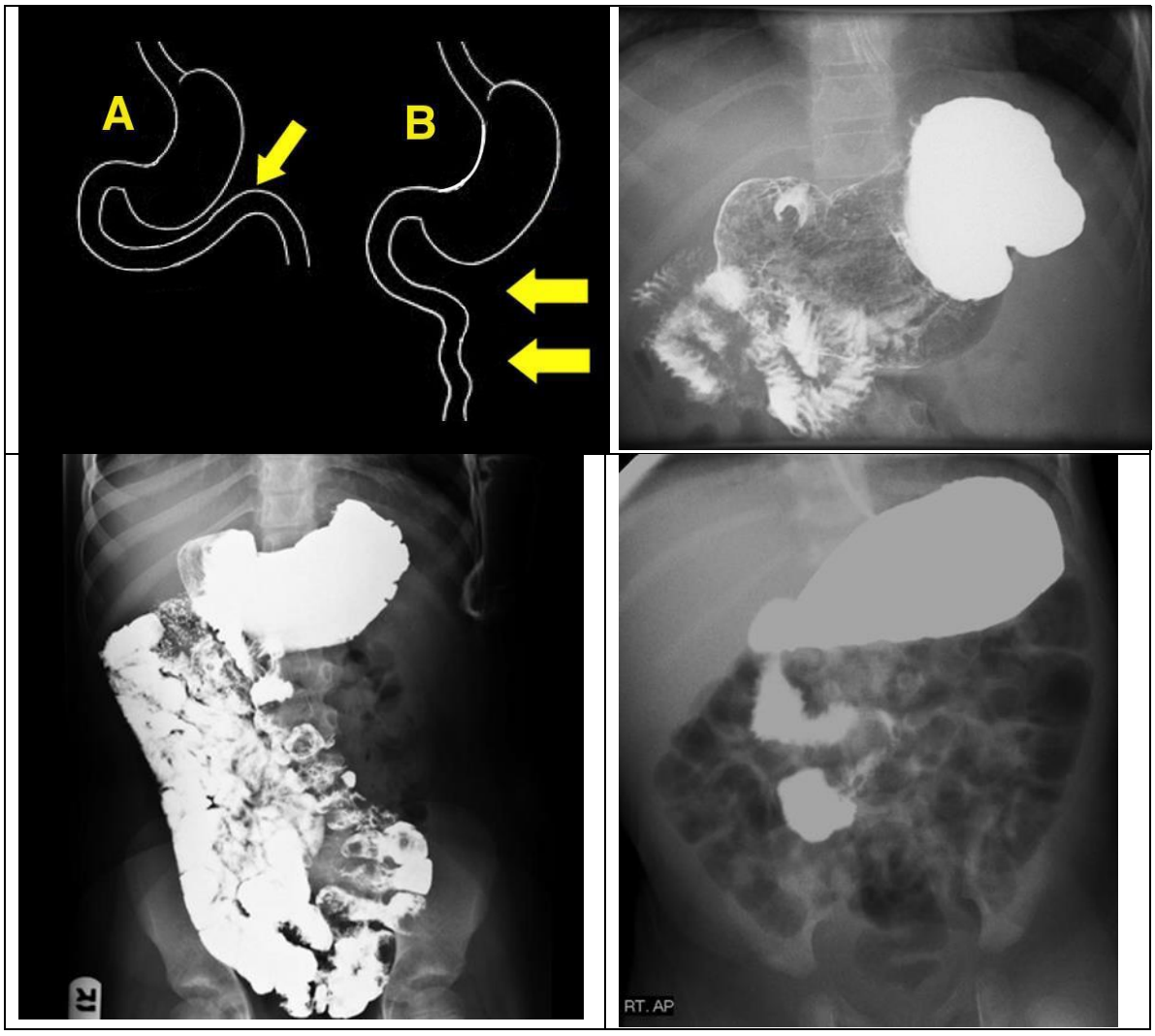
AP View

- DJ junction fails to cross the midline to the left of the left-sided vertebral body pedicle
- DJ junction lies inferior to the duodenal bulb

Lateral View

- 2nd and 3rd duodenum not located posteriorly in retroperitoneal position




A
B
RT. AP

8) Midgut Volvulus

- 60%–80% of those affected present with bilious vomiting in the 1st month of life

Predisposing Factors:

- Malrotation of the small bowel is the major predisposing factor for midgut volvulus.
- In a malrotation, there is abnormal fixation of the small bowel mesentery, which results in an abnormally short mesenteric root.
- This allows the small bowel to twist around its mesentery, causing obstruction and possibly ischemia of the bowel

US / CT Findings:

- ✓ **Inversion of SMA and SMAV relationship**
- ✓ **Whirlpool sign:** bowel rotates around its mesentery, with mesenteric vessels creating the whirls

Upper GI:

Normal DJ Flexure:

- To the left of the left pedicle of the vertebral body
- At the same level or more superior than duodenal bulb

Malrotation:

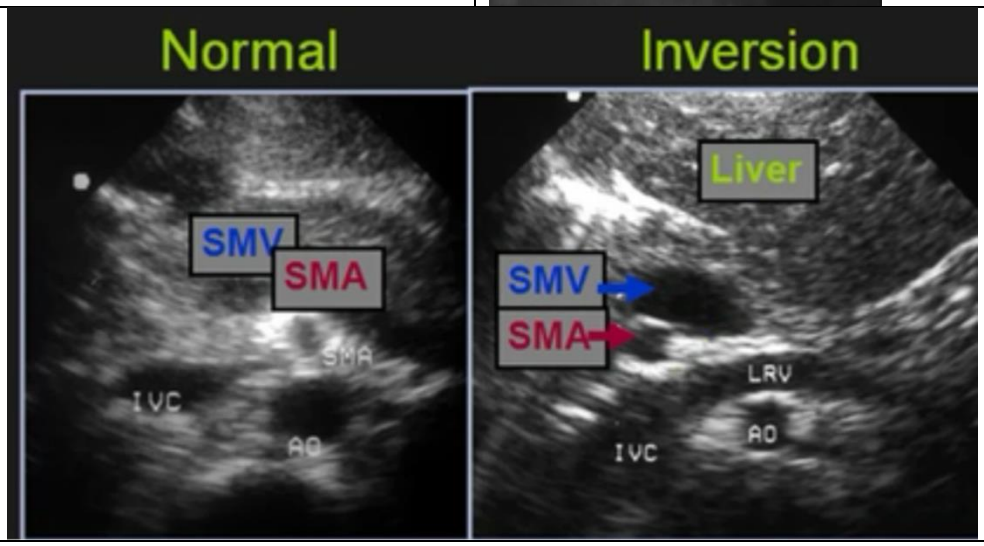
- Abnormal position of duodenojejunal junction
- Abnormal position of cecum by small bowel follow through or barium enema

Volvulus:

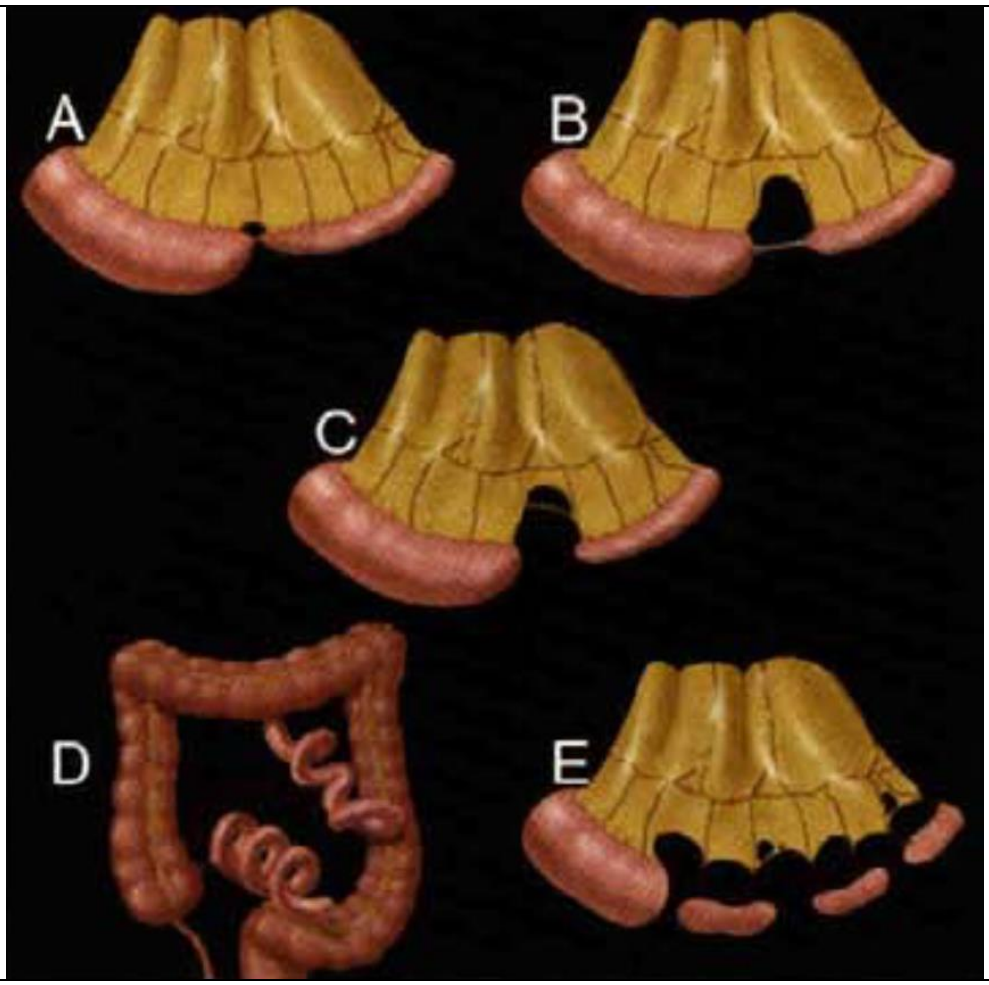
- Cork screw or "Z"shaped appearance of the duodenum which does not cross to the left of midline

Whirlpool sign

Cork screw sign



9) Jejunoileal / Ileal Atresia

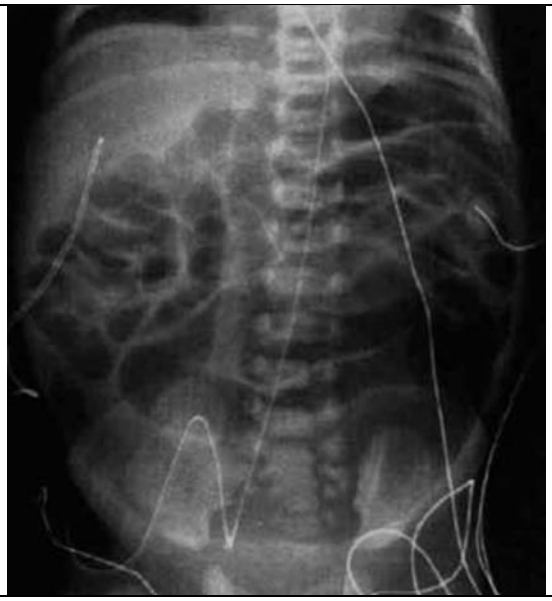


Radiography

- Multiple dilated bowel loops on radiography
- Number of dilated loops reflects level of obstruction:
    - Many loops: Distal obstruction (ileal or colonic)
    - Few loops: Upper obstruction (jejunal or proximal ileal)

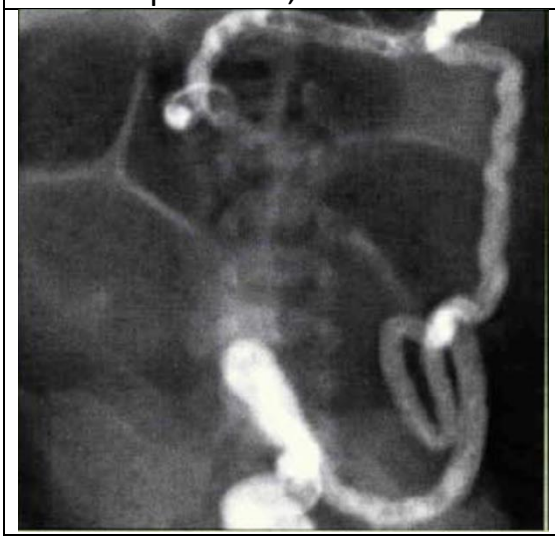
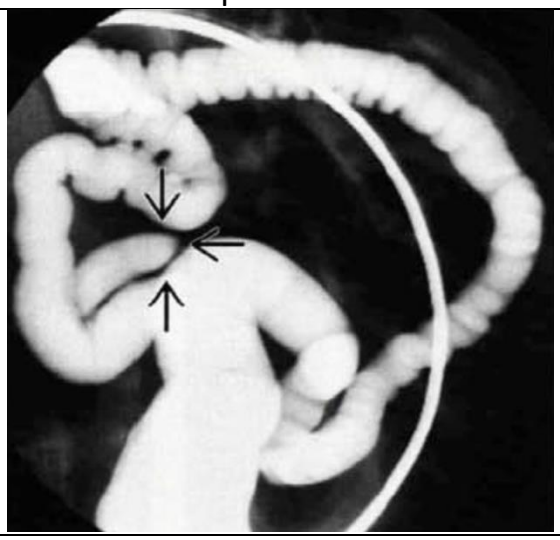
Contrast enema:

- Microcolon
- R/C ratio >1

Few moderately dilated bowel loops suggestive of upper bowel obstruction, likely jejunal atresia.	Multiple moderately dilated bowel loops shows the typical appearance of distal bowel obstruction ileal atresia or colon causes.
	

<u>Contrast Enema:</u>

- Microcolon ; R/C ratio > 1
- Contrast refluxing into the terminal ileum.
- Abrupt termination of the contrast (arrows) in ileal atresia.
- Nonopaciefied, air-filled dilated small bowel loops.

10) Meconium Ileus

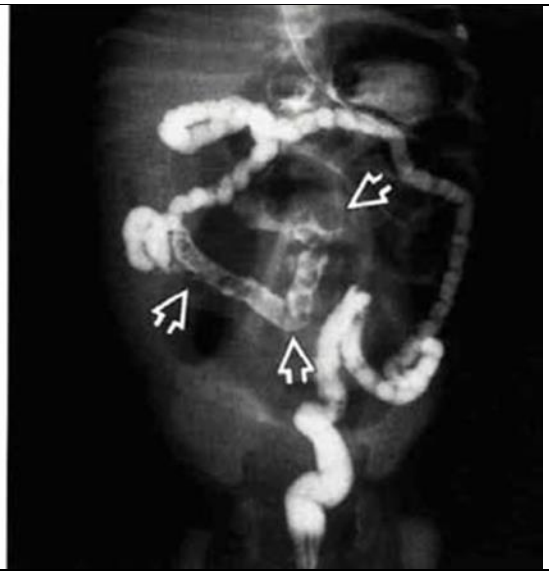
- Neonatal obstruction of the distal ileum due to abnormally thick, tenacious meconium
- Essentially all patients with meconium ileus have ***cystic fibrosis***.
- Terminal ileum obstruction

Palin Radiograph:

- Multiple dilated bowel loops in neonate
- Paucity or absence of air-fluid levels
- "bubbly" appearance of the distended intestinal loops.

Contrast enema:

- Microcolon; R/C ratio > 1
- Meconium-filled terminal ileum



11) Meconium Plug Syndrome / Small Left Colon Syndrome

- Transient functional obstruction of the newborn colon
- Common cause of distal neonatal bowel obstruction
- Abdominal distention
- Delayed or failed passage of meconium (> 24-48 hours)
- Bilious emesis
- Suction rectal biopsy to exclude Hirschsprung disease, especially if persistent symptoms

Palin Radiograph:	**Contrast enema**
Multiple dilated bowel loops in neonate	• R/S ratio > 1 • Small left colon to about the splenic flexure (arrow) • Several meconium plugs.

12) Hirschsprung Disease

- Functional obstruction of the bowel due to lack of intrinsic enteric ganglion cells
    - Myenteric (auerbach) plexus
    - Submucosal (meissner) plexus
- Diagnosis made by rectal biopsy: Absent ganglion cells
- Affected portion always includes the anus and variable length of contiguous colon
- Continuous disease, no proximal without distal involvement

Clinical picture:

- Failure to pass meconium 24-48 hours
- Abdominal distention
- Bilious vomiting
- Constipation since birth
- 90% diagnosed in newborn
- Untreated, HD can lead to toxic megacolon, enterocolitis, sepsis and death
- Surgical resection of affected colon

4 types according to length of aganglionic segment:

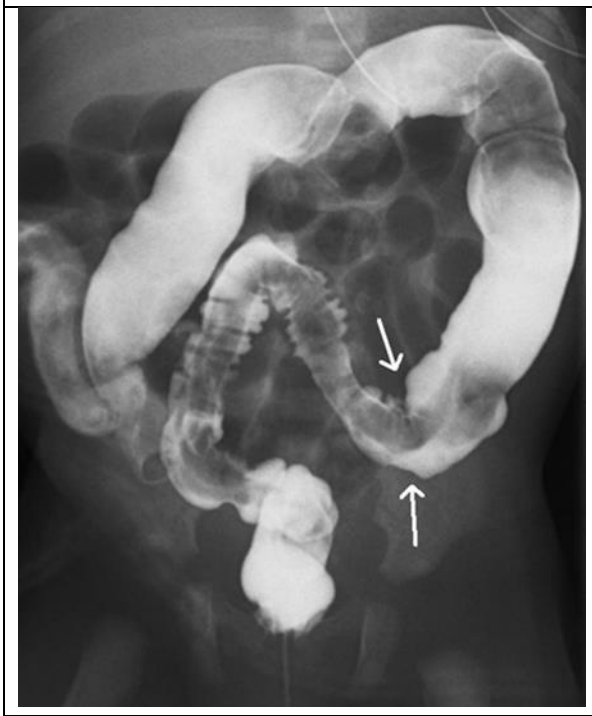
1) **Short segment disease : ~ 75%**
    - Rectal and distal sigmoid colonic involvement only
2) **Long segment : ~ 15%**
    - Typically extends to splenic flexure / transverse colon
3) **Total colonic aganglionosis : 2 - 13%**
    - Also known as zuezler-wilson syndrome
    - Occasional extension of aganglionosis into small bowel
4) **Ultrashort segment disease**
    - 3 - 4 cm of internal anal sphincter only
    - Controversial entity

Palin Radiograph:

- Multiple dilated bowel loops in neonate

Contrast enema:

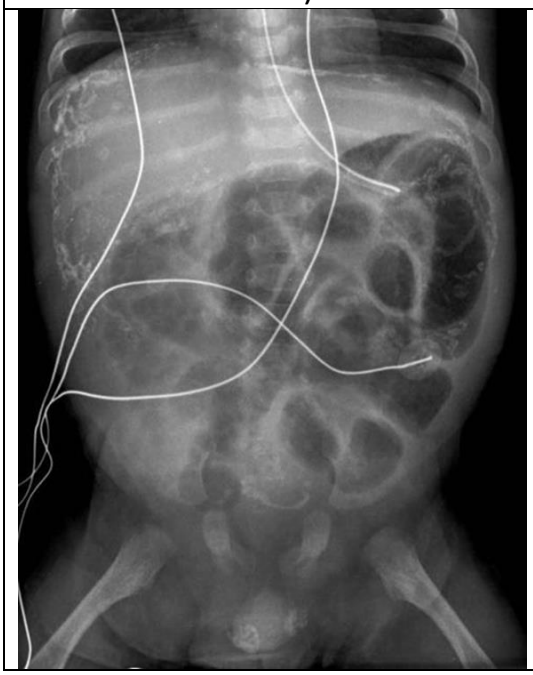
- Denervated colon is small, narrow, spasmodic
- Small= Rectum smaller than sigmoid (**R/S ratio < 1**)
- Spasm = Fasciculations or sawtooth appearance of mucosa of involved colon
- Transition zone from abnormally small distal to dilated proximal colon
- Innervated more proximal bowel is dilated
- Microcolon: Total colonic disease



13) Meconium Peritonitis

- Chemical peritonitis from intra uterine bowel perforation and peritoneal leakage of sterile meconium.
- Most commonly the perforation seals off in utero.
- The extruded meconium may become calcified: Linear, curvilinear, or punctate peritoneal calcifications (86%)

Plain film :

Intra-abdominal (peritoneal) calcification (can be curvilinear, linear or flocculant)	**Meconium PseudoCyst:** A mass containing calcification
	

US findings:

- Highly echogenic linear or clumped foci which represent calcifcation
- can also give a ***snowstorm appearance***
- may show fetal ascites (most common antenatal sonographic finding) and / or polyhydramnios
- may also show associated anomalies such as dilated fetal bowel and / or meconium pseudocysts

14) Anorectal Malformation

(See Anorectal Chapter)

Necrotizing Enterocolitis

- Necrotising enterocolitis (NEC) is the most common gastrointestinal condition in premature neonates.
- It is characterized by inflammation, ischaemia, and permeability of the neonatal bowel wall to bacteria.
- It is potentially life threatening with significant associated morbidity.

Abdominal x-rays :

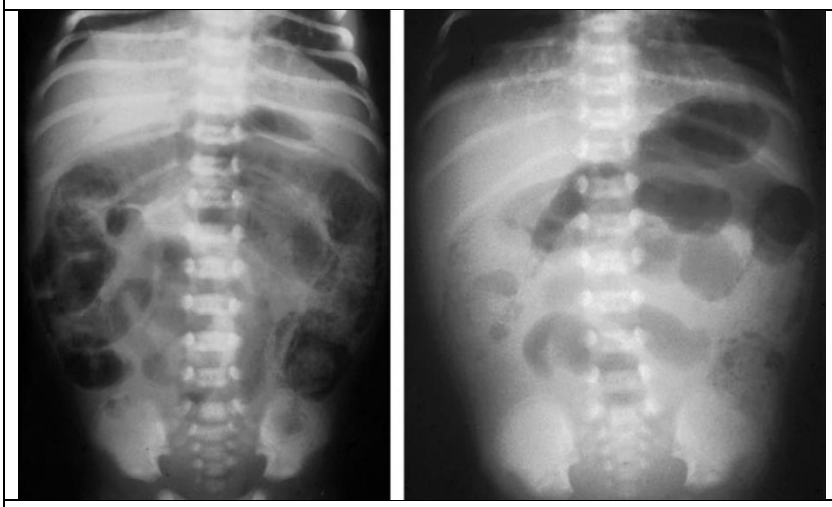
- Dilated bowel loops (often asymmetrical in distribution)
- Loss of the normal polygynal gas shape
- Bowel wall oedema with thumb printing
- Pneumatosis intestinalis (intramural gas)
- Portal venous gas
- Pneumoperitoneum secondary to perforation
- Air on both sides of the bowel (rigler sign)
- Air outlining the falciform ligament (football sign)
- It is important to note that only 50 - 75% of patients with proven perforation will have visible free gas

US:

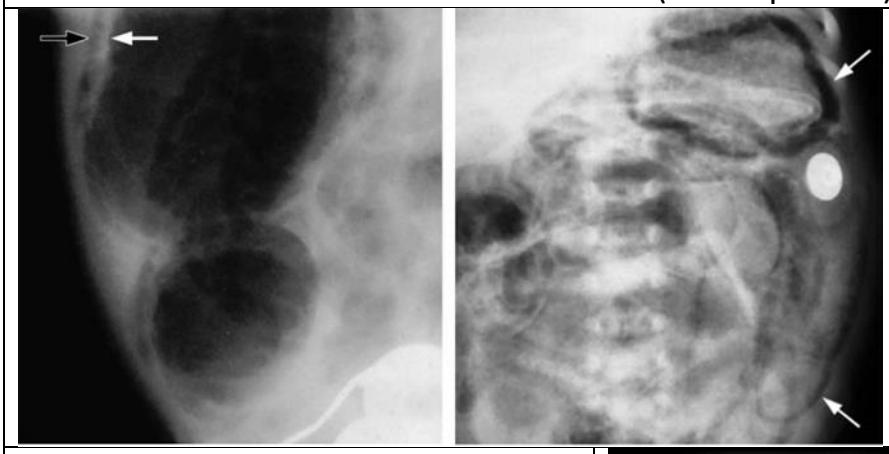
- Bowel wall thickening free fluid
- Alteration of vascular state:
    - Hyper vascular (viable but engorged in early stage)
    - Hypo vascular (infarcted in later stage)
- Intramural gas manifesting as high echo foci within the bowel wall
- Free fluid especially with echogenic debris is suspicious for perforation

An ominous sign

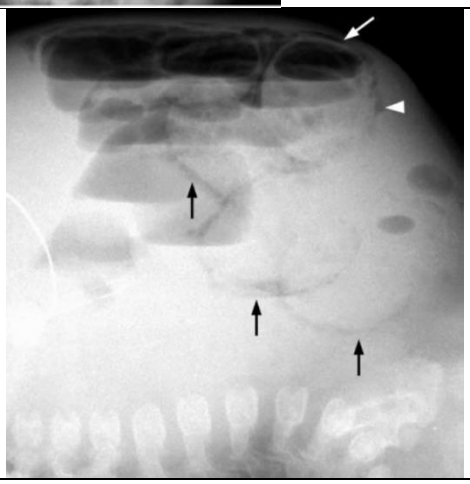
is the change from generalized dilatation to an asymmetric distribution where dilatation is confined to a more localized area of the abdomen



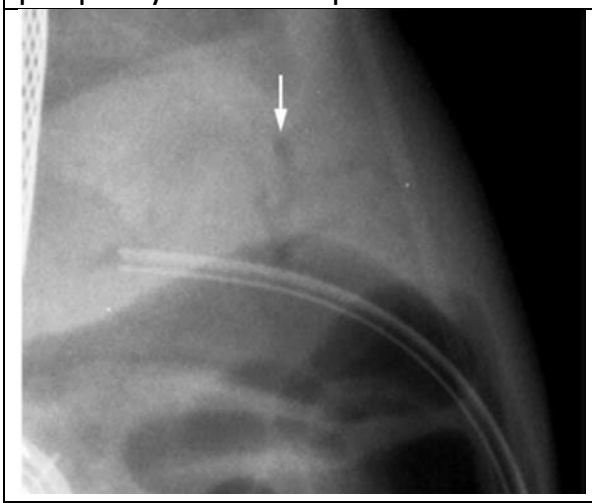
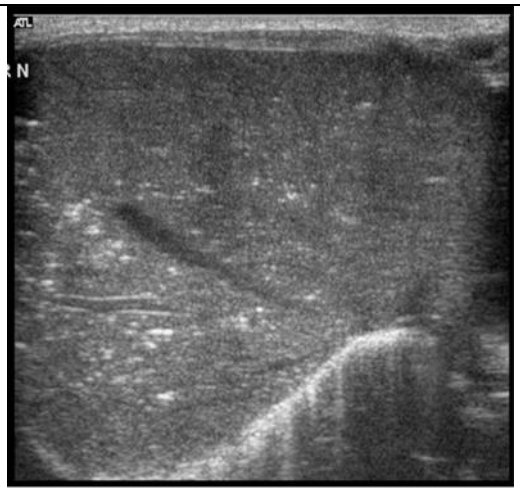
Intramural Gas = Pneumatosis Intestinalis (Linear pattern)



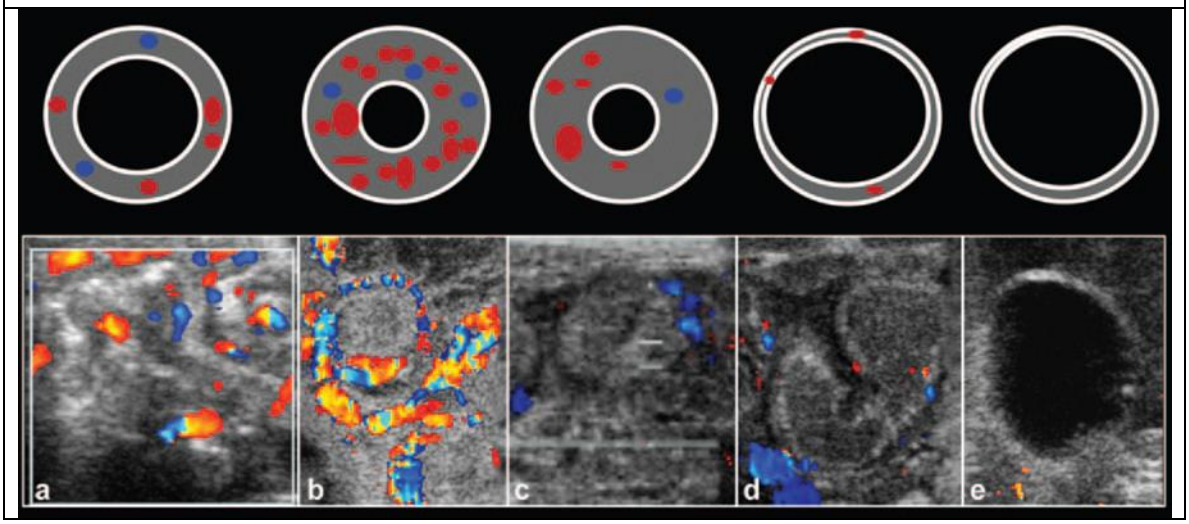
Cross-table lateral abdominal radiograph of a neonate
Marked dilatation of bowel with gas and fluid
Extensive intramural gas (arrows).



Portal Venous Gas:

Branching, linear, radiolucent vessels that may extend from the region of the main portal vein toward the periphery of both hepatic lobes.	diffuse branching echogenic foci
	

(a) The diagram shows normal bowel wall thickness and perfusion.
(b) The changes of NEC are shown with bowel wall thickening and hyperemia.
(c) The bowel wall thickening persists, but the perfusion has diminished.
(d) As the process progresses in more severely affected neonates, the mucosa starts to slough and the bowel wall becomes much thinner, although some perfusion persists.
(e) Sloughing continues, the bowel wall becomes asymmetrically thinned, and blood flow ceases.



Neonatal Pneumoperitoneum

Causes:

Perforated hollow viscus

- Necrotizing enterocolitis (NEC) : most common
- Meconium ileus in cystic fibrosis
- Hirschsprung disease
- Intestinal atresia or web
- Peptic ulcer disease

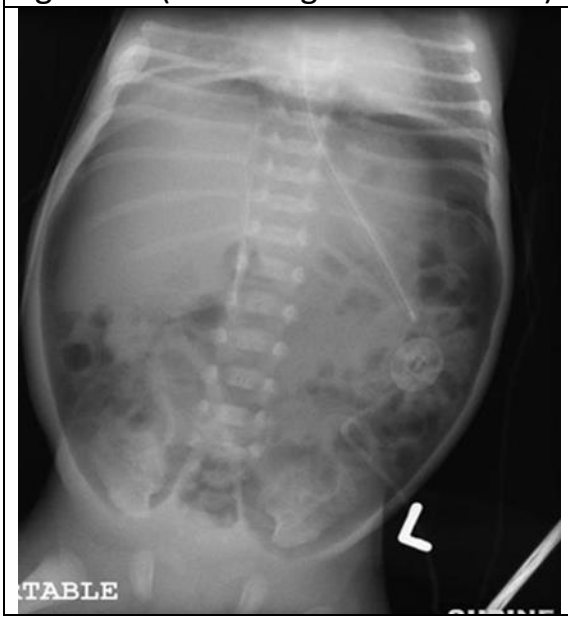
Iatrogenic

- Intubation / mechanical ventilation
- Rectal thermometer
- Enema

❖ Abdominal X-ray Supine Signs

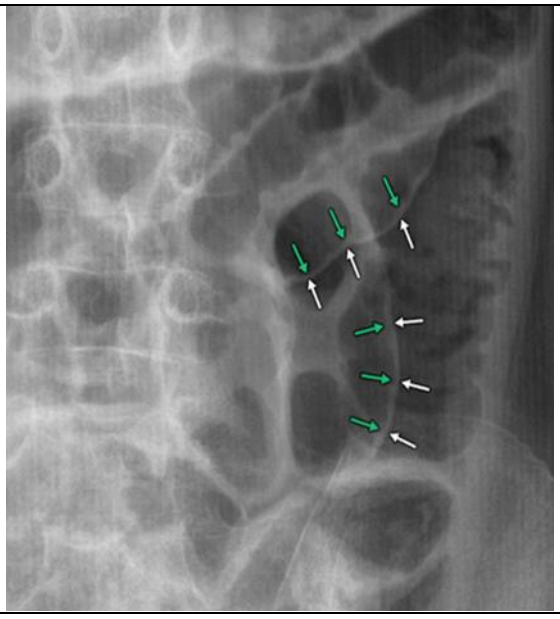
1) Football" Sign:

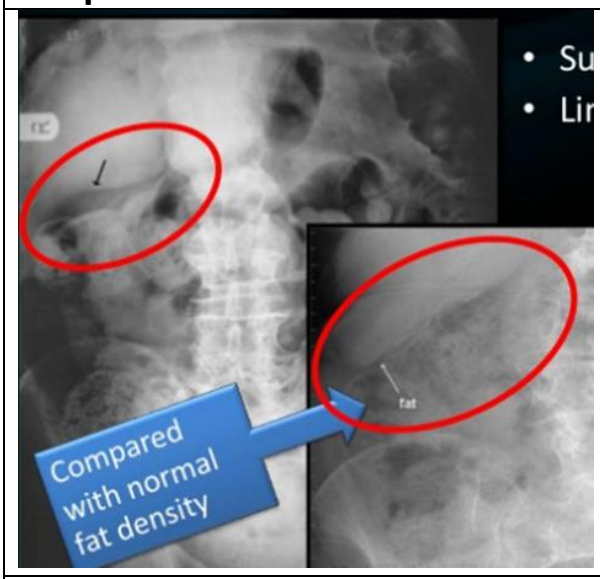
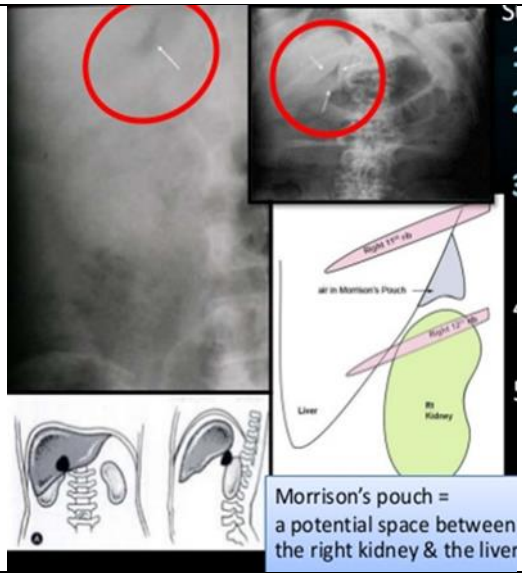
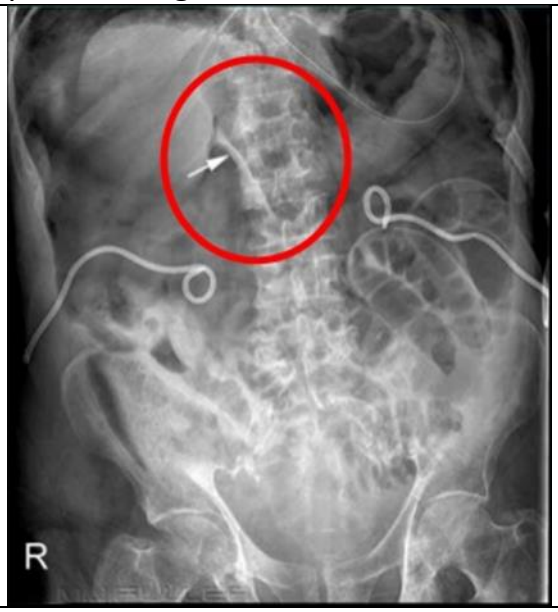
The gas outlines the whole of the peritoneal cavity, the undersurface of the diaphragm, and the falciform ligament (the lacing of the football).

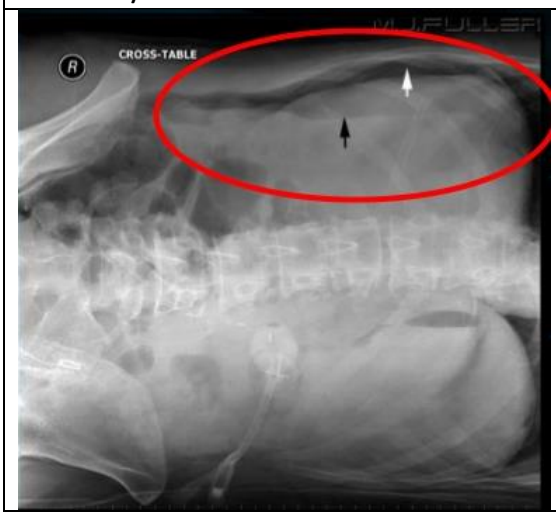
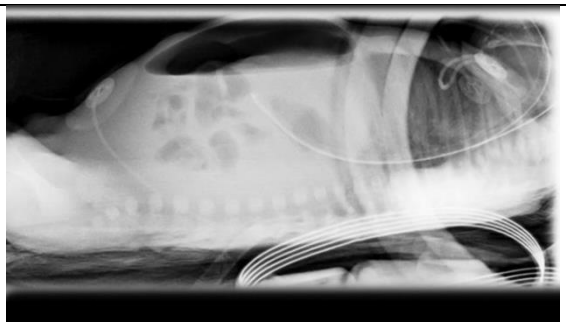


2) Rigler's sing:

Bowel wall outlined between intraluminal gas and extra-luminal free peritoneal gas.



3) **Anterior Subhepatic Free air space**	4) **Morrison's pouch free gas**
	
5) Air anterior to ventral surface of liver: Uneven density in geographical shape	***6) <u>Falciform ligament sign:</u>*** Becomes oultined with free peritoneal gas
	

7) <u>Triangle sing:</u> Small triangle of free peritoneal gas between large bowel and flank	***8) <u>Pneumo-Retroperitoneum:</u>*** Free retroperitoneal air is seen surrounding lateral border of kidney
9) <u>Left Lateral Decubitus view:</u> Free peritoneal air between abdominal wall and liver and air / fluid levels	10) ***<u>Cross table lateral view:</u>***
	

Toxic Megacolon

Complication that can be seen in:

- Inflammatory bowel disease: UC and Crohn's disease
- Infectious colitis

Clinical Presentation:

- Systemic toxicity
  - Fever of greater than 101.5
  - Tachycardia greater than 120/min
  - Leukocytosis of greater than 10.5 thousand
  - Anemia
- Diarrhea, abdominal pain, rectal bleeding and vomiting
- Dehydration
- Altered mental status
- Hypotension

Imaging Findings:

- The colon (typically transverse colon) becomes dilated > 6 cm (usually greater).
- Loss of haustral markings
- Pseudopolyps often extending into the lumen.
- Thumbprinting from mucosal oedema may be present.
- There may be signs of pneumoperitoneum if dilatation has progressed to cause perforation
- Barium enema should not be performed

GIT

Anorectal Region

Rectal Anatomy

- The rectum extends from the upper end of the anal canal to the rectosigmoid junction.
- It is 15 cm in length.
- Proximal limit => rectosigmoid junction => Sacral promontory
- Distal limit => anorectal angle= anorectal junction => anorectal muscle ring

The rectum is anatomically divided into 3 segments:

- Lower third = 0-5 cm above anorectal angle
- Middle third = 5-10 cm above anorectal angle
- Upper third = 10-15cm above anorectal angle

T2 Normal Recta Wall

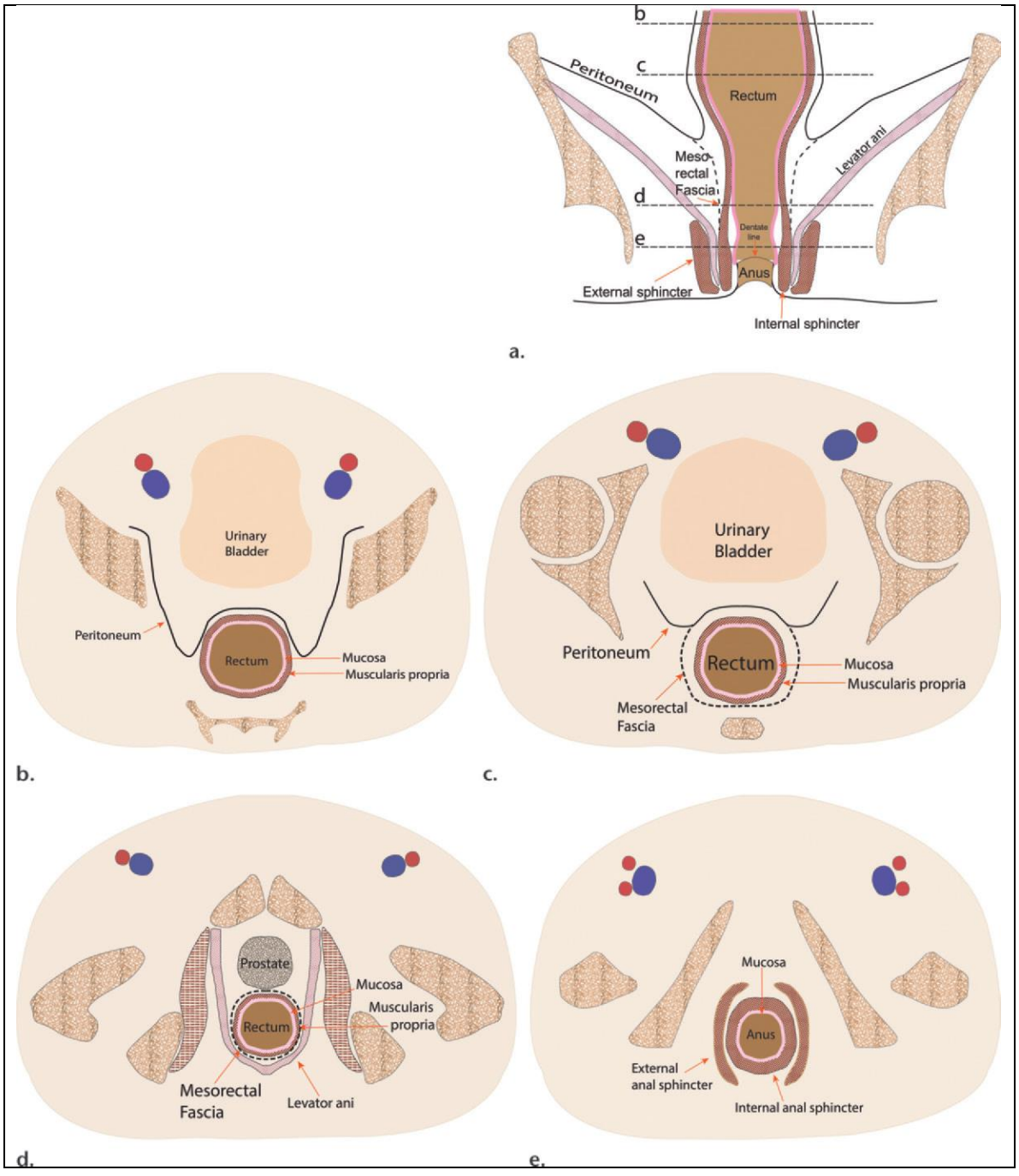
- Mucosa & Submucosa => High signal
- Muscularis propria => Low signal
- Mesorectal Fat => High signal
- Mesorectal fascia => Thin, hypointense line surrounding the hyperintense mesorectal fat.
- Tumor => Intermediate signal between high signal of mesorectal fat and low signal of the muscular layer.

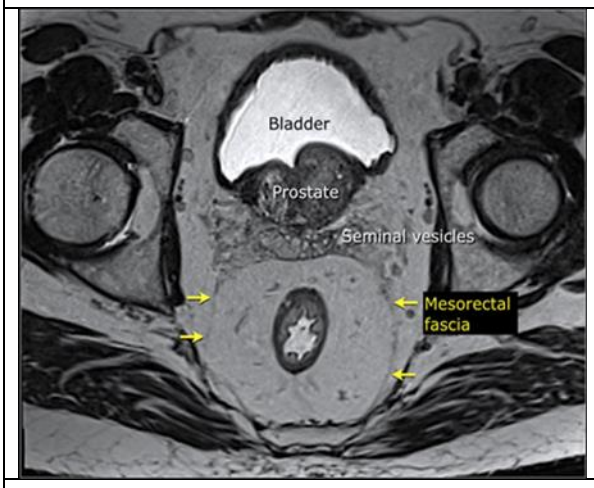
Arterial supply

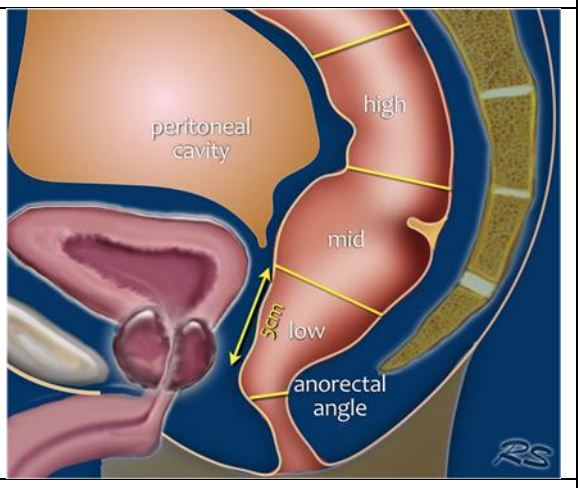
- Superior rectal artery: terminal branch of inferior mesenteric artery
- Middle rectal artery: branch of internal iliac artery
- Inferior rectal artery: branch of the internal pudendal artery

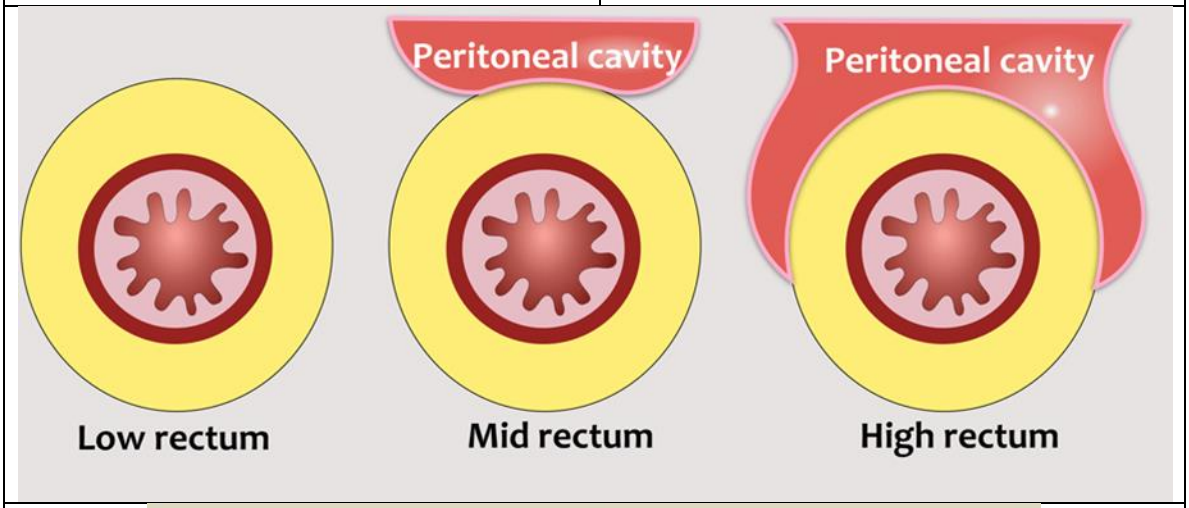
Lymphatic drainage

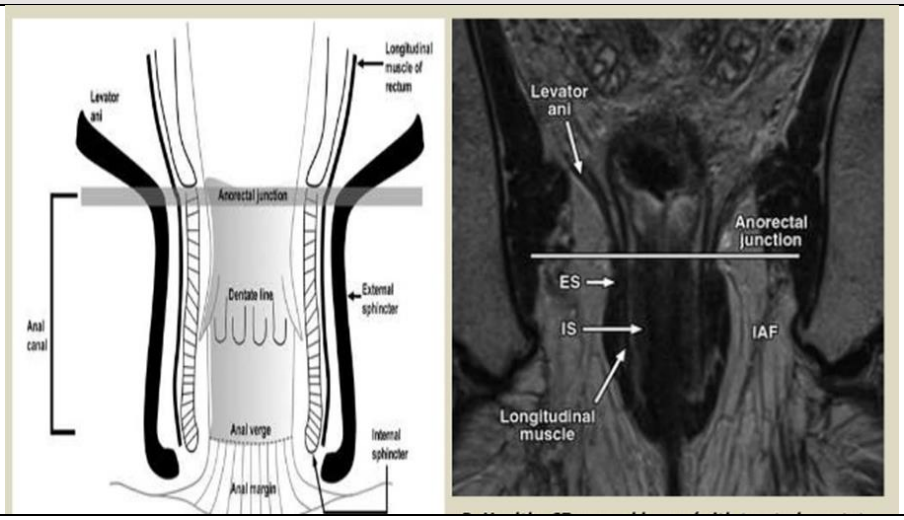
- Upper third: Lymphatics drain along superior rectal vessels => Inferior mesenteric group
- Lower two-thirds: Lymphatics drain along the middle rectal vessels => Internal iliac group.


b
c
Peritoneum
Rectum
Meso-
rectal
Fascia
Levator ani
d
e
Dentate
line
Anus
External sphincter
Internal sphincter
a.
Urinary
Bladder
Peritoneum
Rectum
Mucosa
Muscularis propria
b.
Urinary
Bladder
Peritoneum
Rectum
Mucosa
Muscularis propria
Mesorectal
Fascia
c.
Prostate
Mucosa
Muscularis
propria
Rectum
Mesorectal
Fascia
Levator ani
d.
Mucosa
Anus
External
anal sphincter
Internal anal sphincter
e.


Bladder
Prostate
Seminal vesicles
Mesorectal fascia


peritoneal cavity
high
mid
low
5cm
anorectal angle
RS


Peritoneal cavity
Peritoneal cavity
Low rectum
Mid rectum
High rectum


Levator ani
Longitudinal muscle of rectum
Anorectal junction
Dentate line
External sphincter
Anal canal
Anal verge
Internal sphincter
Anal margin
Levator ani
Anorectal junction
ES
IS
IAF
Longitudinal muscle

Embryology

- **3- to 5th week:** The urinary, genital, and distal gastrointestinal tracts empty into a common channel called the cloaca.
- **6th week:** the cloaca is segregated into an anterior urogenital sinus and a posterior intestinal canal by the cranial-to-caudal descent of the urorectal septum.
- **7th week:** The caudal extension of the urorectal septum develops into the perineal body, dividing the perineum into the urogenital triangle ventrally and the anal triangle dorsally.

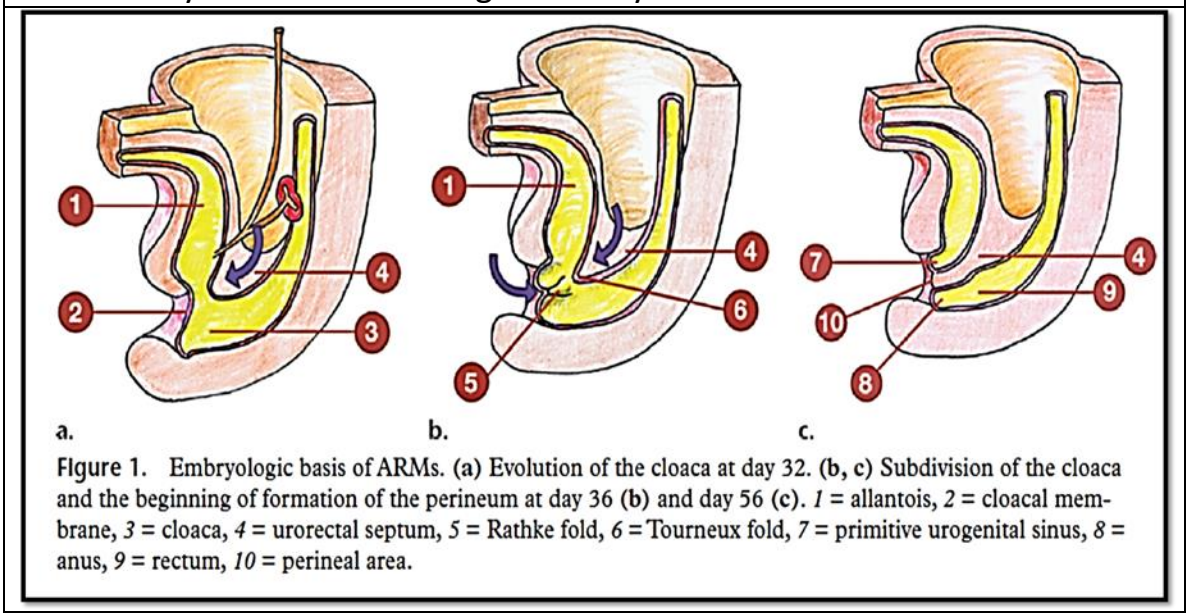


Figure 1. Embryologic basis of ARMs. (a) Evolution of the cloaca at day 32. (b, c) Subdivision of the cloaca and the beginning of formation of the perineum at day 36 (b) and day 56 (c). *1* = allantois, *2* = cloacal membrane, *3* = cloaca, *4* = urorectal septum, *5* = Rathke fold, *6* = Tourneux fold, *7* = primitive urogenital sinus, *8* = anus, *9* = rectum, *10* = perineal area.

Anorectal Malformation

- Anorectal malformations (ARMs) are a complex group of congenital anomalies involving the distal anus and rectum, as well as the urinary and genital tracts in a significant percentage of cases.

Most Common Associated Anomalies in Patients with ARMs

Affected System	Anomalies
Cardiovascular	Tetralogy of Fallot, atrial septal defect, ventricular septal defect, dextrocardia, coarctation of the aorta
Gastrointestinal	Esophageal atresia; duodenal, jejunal, or ileal atresia; absent colon; intestinal malrotation; volvulus; Meckel diverticulum
Musculoskeletal	Hip dislocation or dysplasia, fusion of iliac bones, Madelung deformity, arthrogryposis, clubfoot, polydactyly, syndactyly, limb deficiency
Spinal cord and spine	Sacral agenesis, vertebral dysplasia, spina bifida, tethered cord, myelomeningocele
Urogenital	Vesicoureteral reflux, hydronephrosis, bilateral or unilateral renal agenesis, renal dysplasia, renal ectopia, horseshoe kidney, polycystic kidney, renal duplication, megaureter, exstrophy of the bladder, micropenis, hypospadias, double uterus or double vagina, vulvovaginal atresia, ambiguous genitalia

Most Common Syndromes or Multisystemic Conditions Associated with ARMs

Type of Associated Entity	Syndromes or Multisystemic Conditions
Associations of congenital anomalies	VACTERL (*V*ertebral anomalies, *A*nal atresia, *C*ardiac malformations, *T*racheo-*E*sophageal fistula, *R*enal and *L*imb anomalies), OEIS (*O*mphalocele, *E*xstrophy, *I*mperforate anus, *S*pinal defects), MURCS (*MÜ*llerian duct aplasia, *R*enal aplasia, *C*ervicothoracic *S*omite dysplasia)
Chromosomopathies	Trisomy 13, 18, and 21; parental unidisomy 16; deletion of 22q11.2 and 13q; heterotaxia
Syndromes	Baller-Gerold, cat-eye, caudal regression, Christian, Currarino triad, Down, facio-auriculo-vertebral, Feingold, fetal alcohol, FG, Fraser, Ivemark, Johanson-Blizzard, kabuki, Klippel-Feil, Lowe, MIDAS, Okihiro, Opitz, Pallister-Hall, Pallister-Killian, Rieger, Townes-Brock, ulnar-mammary, Walker-Warburg

❖Classification of ARMs

Wingspread classification of 1984:

- It divides ARMs into three types—low, intermediate, and high—depending on whether the rectal pouch is located below, at the level of, or above the puborectal sling, respectively, with special categories for cloacal and rare malformations.

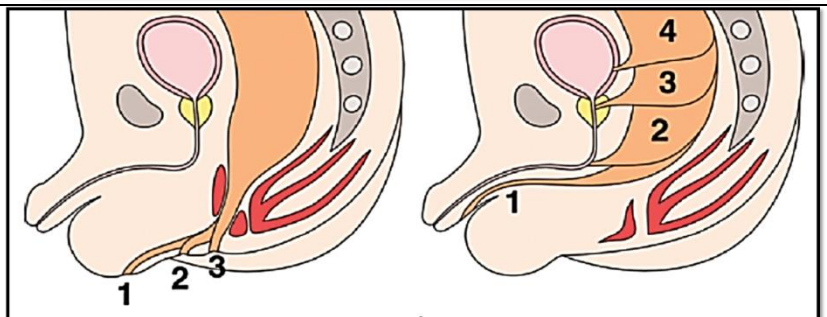
Krickenbeck Classification of 2005:

- based mainly on the presence or absence of fistulas and their type and location, as well as the position of the rectal pouch.

❖Males ARMs:

Comparison of Wingspread and Krickenbeck Classifications of ARMs in Male Patients

Type of ARM	Wingspread Classification (1984)	Krickenbeck Classification (2005)
Low	Anal stenosis, anocutaneous fistula	Anal stenosis, imperforate anus without fistula, rectoperineal fistula
Intermediate	Anal agenesis without fistula or with recto-urethral bulbar fistula	Anal or anorectal agenesis without fistula or with recto-urethral bulbar, recto-urethral prostatic, or rectovesical fistula*
High	Rectal atresia, anorectal agenesis without fistula or with recto-urethral prostatic fistula	



a. b.

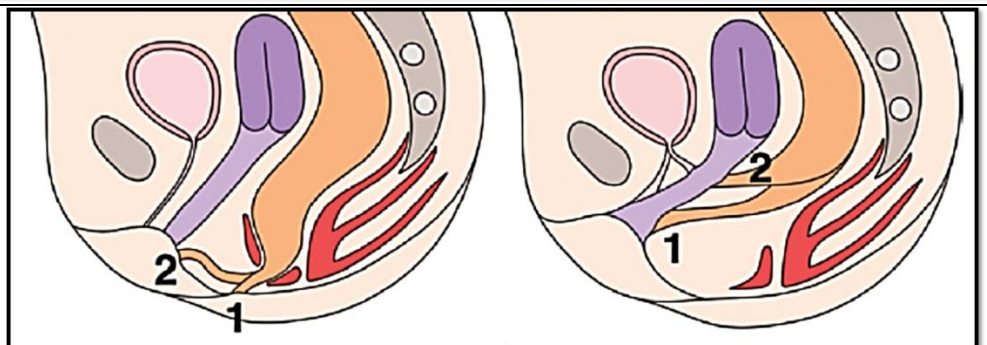
Figure 2. Possible locations of fistulas in males with ARMs according to the Krickenbeck classification. **(a)** Low-type ARMs have an external anocutaneous opening in the scrotum *(1)* or perineum (*2*, *3*). **(b)** Intermediate- and high-type ARMs extend anteriorly to the base of the penis *(1)*, the bulbar *(2)* or prostatic *(3)* urethra, or the urinary bladder *(4)*.

Low type ARM:	**Intermediate – High type ARM:**
• Anal stenosis	• Recto-penile fistula
• Imperforate anus without fistula.	• Recto-urethral-bulbar fistula
• Recto-perineal fistula	• Recto-urethral-prostatic fistula
• Recto-scrotal fistula	• Recto-bladder neck fistula

❖Females ARMs

Comparison of Wingspread and Krickenbeck Classifications of ARMs in Female Patients

Type of ARM	Wingspread Classification (1984)	Krickenbeck Classification (2005)
Low	Anal stenosis, anal agenesis without fistula or with external fistula	Anal stenosis, imperforate anus without fistula, anal agenesis with rectoperineal or rectovestibular fistula
Intermediate	Anal agenesis without fistula or with rectovestibular or rectovaginal fistula	Anal or anorectal agenesis without fistula, rectal atresia, cloacal malformations with short (<3 cm) or long (>3 cm) common canal*
High	Rectal atresia, anorectal agenesis without fistula or with rectovaginal fistula, cloacal malformations	



a. b.

Figure 3. Possible locations of fistulas in females with ARMs according to the Krickenbeck classification. **(a)** Low-type ARMs have an external opening in the perineum *(1)* or vestibular area *(2)*. **(b)** Cloacal anomaly is a complex anatomic disorder that manifests as a unique external perineal opening with a short *(1)* or long *(2)* common canal for the genital, urinary, and digestive systems. Isolated rectovaginal fistulas are extremely rare and are considered a variant of cloacal anomaly.

Low type ARM:	**Intermediate – High type ARM:**
Anal stenosis Imperforate anus without fistula. Recto-perineal fistula Recto-vestibular fistula	Cloaca with short common channel (< 3 cm) Cloaca with long common channel (> 3 cm)

❖Role of Imaging:

- ✓ **Accurate diagnosis of the type of ARM.**
- ✓ **Presence or absence of fistulas.**
- ✓ **Identification of associated anomalies**

❖Radiographs

- Radiographs of the thorax, spine, and pelvis in the anteroposterior and lateral views may allow identification of
    - Cardiac, costal, and vertebral anomalies

❖Perineal US

- is an excellent method for evaluating the location of the distal rectal pouch and the anatomy and location of any rectourogenital fistulas
- 10–12- MHz high-resolution linear-array transducer
- Transperineal approach
- Child in a supine position and the pelvis and legs elevated.
- The bowel-skin distance between the rectal pouch and the anus is then measured in the midline sagittal plane.
    - >15 mm => high type of ARM
    - <15 mm => low type of ARM

❖Abdominal US and pelvic US

- are usually performed with an 8-MHz transducer,
- Patient in both prone and supine positions.
- This technique facilitates optimal screening of the entire urinary tract, including the bladder, bladder neck, and posterior urethra in boys.

❖Spinal US

- is currently accepted as a safe and inexpensive screening test for detection of spinal dysraphism .
- 12-MHz high-resolution lineararray transducer
- in both midsagittal and transverse planes
- The patient in a prone position.
- Allows identification of level of medullary cone and demonstration of a presacral mass.
- Tethered cord syndrome is found in a significant number of children with ARMs, regardless of the type of malformation.

❖VCUG

- is mandatory in patients with pathologic renal or vesical findings at US or clinical suspicion of rectourinary fistulas (meconium in the urine).
- Administration of a hydrosoluble contrast material through a bladder catheter enables identification of associated congenital urinary problems, mainly vesicoureteral reflux.
- This method may also demonstrate rectourinary fistulas

❖High-pressure distal colostography

- is the most effective imaging technique for demonstrating fistulas.
- It consists of manual injection of hydrosoluble contrast material through a Foley catheter inserted into the distal colostomy, which is sealed by means of gentle traction of the inflated balloon

❖Spinal MR imaging

- is the most sensitive imaging modality for detecting vertebral and spinal cord anomalies
- It is mandatory in cases of vertebral anomalies, sacral dysplasia, or abnormal results at spinal US.

❖Pelvic MR imaging

- is used in children with ARMs to evaluate both the real position of the rectal pouch and the size, morphology,
- Grade of development of the sphincteric muscles before definitive surgical correction.
- The final prognosis of ARMs depends significantly on the grade of development of these muscles.

MRI Planes:

- Axial images => parallel to PCL
- Coronal images => perpendicular to PCL.
- Midsagittal plane allows evaluation of the sphincteric muscles posterior to the prostate in males or the vagina in females along with the curved structure of the levator ani muscle

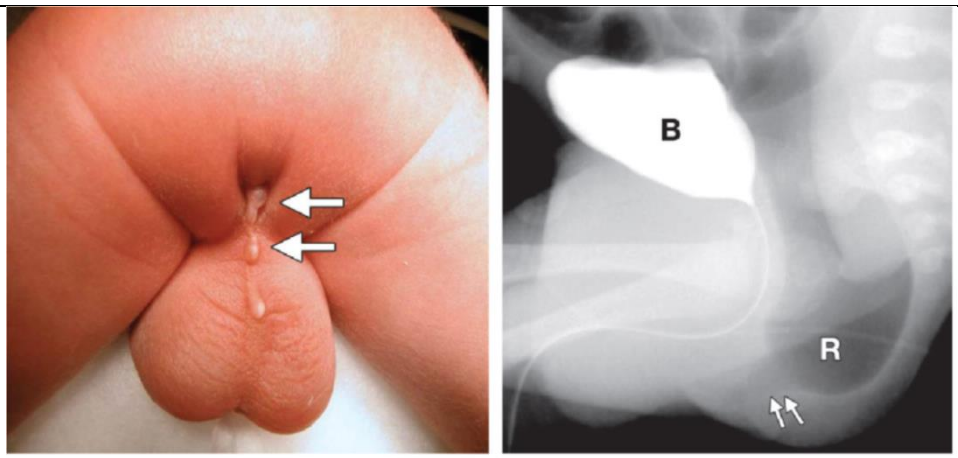
MRI Protocol:

- Axial T1- and T2 of the pelvis parallel to PCL.
- Coronal T1 and T2 of the pelvis perpendicular to PCL.
- Midsagittal T1 and T2.
- +
- Sagittal T1- and T2- of the whole spine and posterior cranial fossa
- Axial T1- and T2- of the lumbar spine are required.

PCL:

Pubococcygeal line => radiological landmark for the upper border of the levator ani muscle.

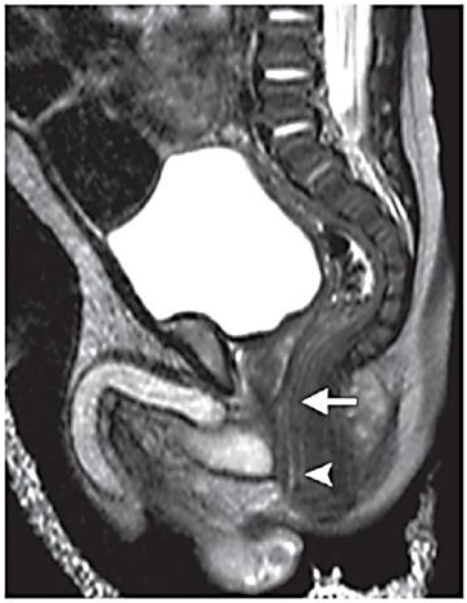
- If it is above PCL=> high ARM +/- fistulous.
- If it is below PCL => low ARM.
- If it is at PCL => Intermediate ARM



a. b.

Figure 9. Low ARM without a fistula in a boy. **(a)** Photograph shows perineal pearls at the midscrotal line (arrows) but no external opening. **(b)** VCUG image at day 1 shows no communication between the bladder *(B)* and distal rectum *(R)*. The air-filled anal canal can be followed to the subcutaneous level (arrows), anterior to the normal position of the anus.

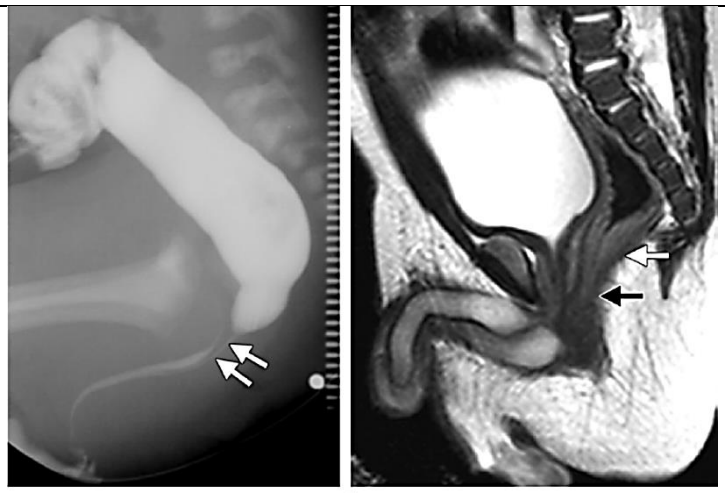
a.



b.

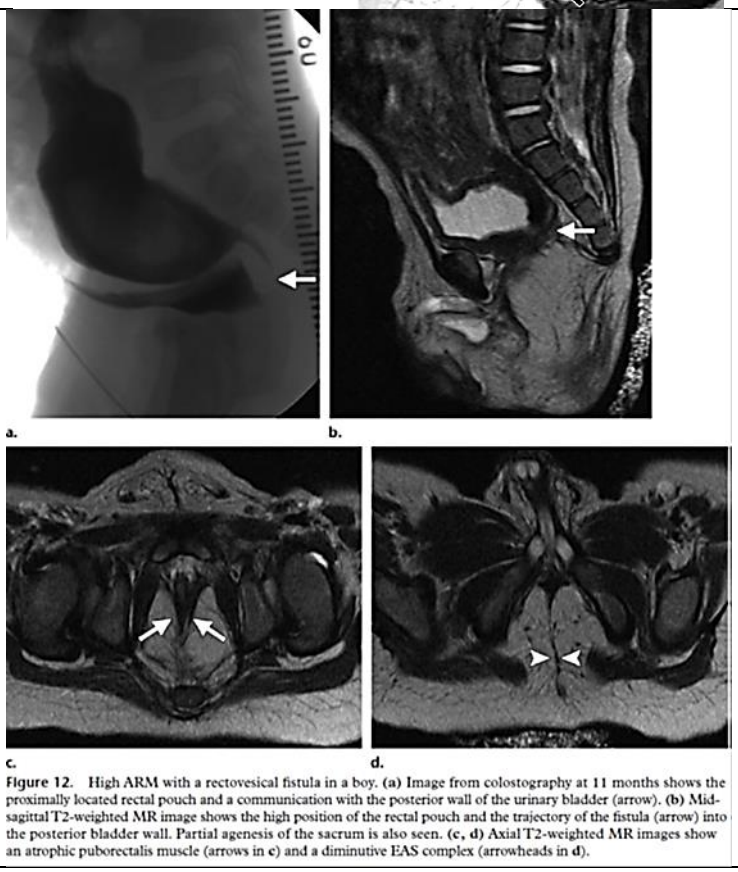
Figure 10. Low ARM with a perineal fistula in a boy. **(a)** Photograph shows normal position of the imperforate anus (arrowhead) and the external opening of a fistula (arrow). **(b)** Midsagittal T2-weighted MR image shows the rectoperineal fistula (arrowhead). The anteriorly displaced anorectum (arrow) is seen below the level of the levator ani muscle. **(c)** Axial T2-weighted MR image at the perineal level shows good development of the EAS (arrow). Note the ventral interruption of the sphincter fibers (arrowheads), a finding that corresponds to the fistula.

c.



a. b.

Figure 11. Intermediate or high ARM with a recto–urethral bulbar fistula in a boy. **(a)** Image from colostography shows a rectourethral fistula (arrows) at the level of the bulbar urethra. **(b)** Sagittal T2-weighted MR image shows the rectal pouch (white arrow) ending at the level of the levator ani muscle and the fistula (black arrow) extending anteriorly to the bulbar urethra. **(c)** Axial T2-weighted MR image at the pubococcygeal level shows an anteriorly located anorectum (white arrow) with an asymmetric and underdeveloped puborectalis muscle (black arrows).



a. b.

c. d.

Figure 12. High ARM with a rectovesical fistula in a boy. **(a)** Image from colostography at 11 months shows the proximally located rectal pouch and a communication with the posterior wall of the urinary bladder (arrow). **(b)** Midsagittal T2-weighted MR image shows the high position of the rectal pouch and the trajectory of the fistula (arrow) into the posterior bladder wall. Partial agenesis of the sacrum is also seen. **(c, d)** Axial T2-weighted MR images show an atrophic puborectalis muscle (arrows in **c**) and a diminutive EAS complex (arrowheads in **d**).

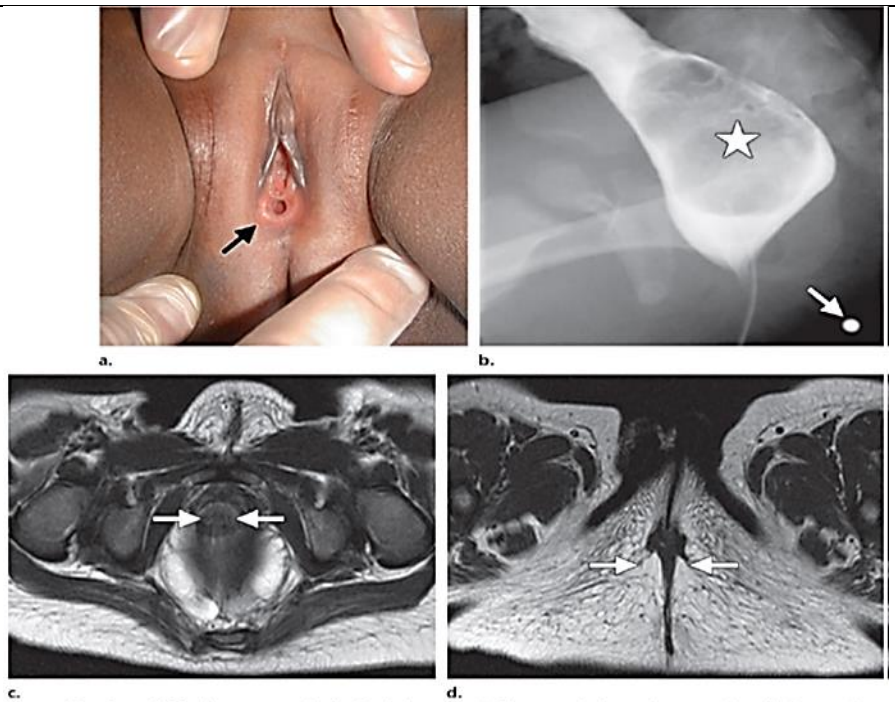


Figure 13. Low ARM with a rectovestibular fistula in a girl. **(a)** Photograph shows the external vestibular opening (arrow) of a rectovestibular fistula. **(b)** Image from colostography after catheterization of the fistula shows the position of the rectal pouch, which is located below the pubococcygeal line. ★ = fecaloma, arrow = normal position of the anus. **(c)** Axial T2-weighted MR image at the level of the pubococcygeal plane shows the ventrally mislocated anorectum (arrows). **(d)** Caudal image shows the EAS complex (arrows) posterior to the fistula.

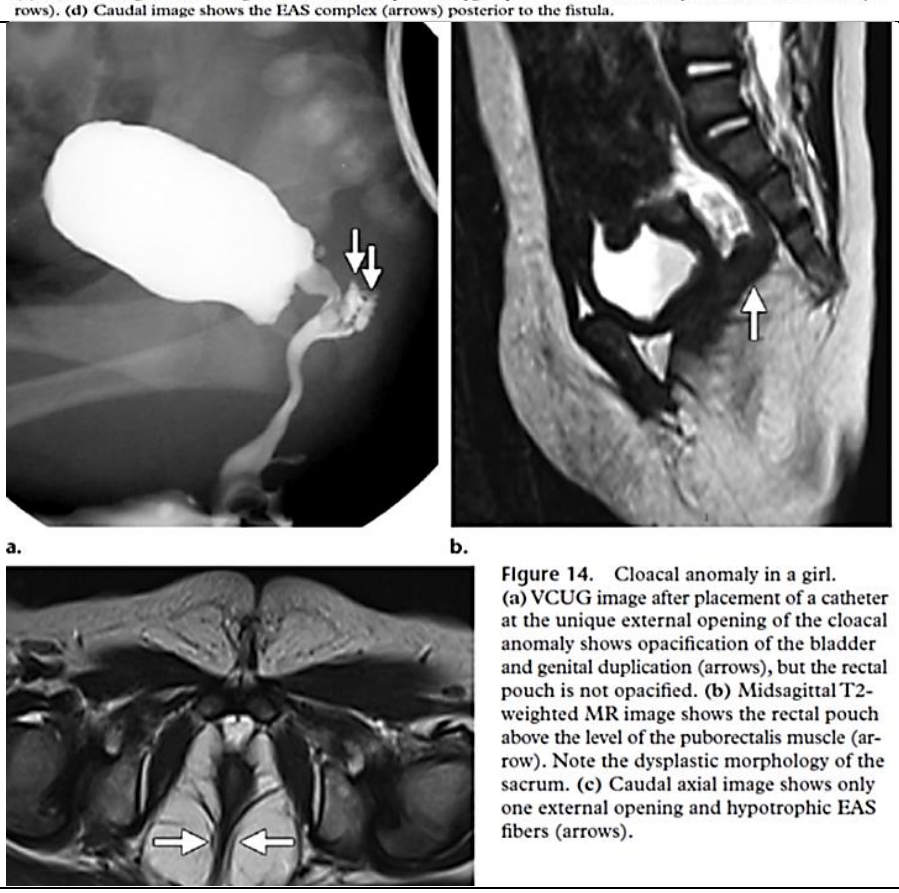


Figure 14. Cloacal anomaly in a girl. **(a)** VCUG image after placement of a catheter at the unique external opening of the cloacal anomaly shows opacification of the bladder and genital duplication (arrows), but the rectal pouch is not opacified. **(b)** Midsagittal T2-weighted MR image shows the rectal pouch above the level of the puborectalis muscle (arrow). Note the dysplastic morphology of the sacrum. **(c)** Caudal axial image shows only one external opening and hypotrophic EAS fibers (arrows).

Perianal Fistula

- The anal canal is a cylindrical structure surrounded by two muscular layers, the internal and external sphincters.

Internal Sphincter

- Composed of smooth muscle
- Inner circular fibers
- Involuntarily
- Responsible for 85% of the resting tone of the anal canal.

External Sphincter Complex:

- Deep, superficial, and subcutaneous external sphincter muscles + Puborectalis muscle + Merges proximally with the levator plate of the pelvic floor.
- Outer striated muscle
- Contributes only 15% of the resting anal tone
- Strong voluntary contractions prevent defecation

Intersphincteric Plane

- Fat plane between the internal and external sphincter.

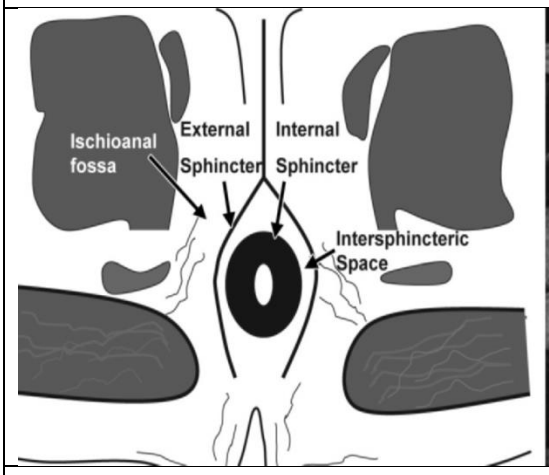
Epidemiology:

- Prevalence: 0.01%
- Male/ female ratio 2:1
- Young adult.
- Patients most commonly present with :-
- Discharge (65%)
- Local pain due to inflammation
- some fistulas may be entirely asymptomatic.

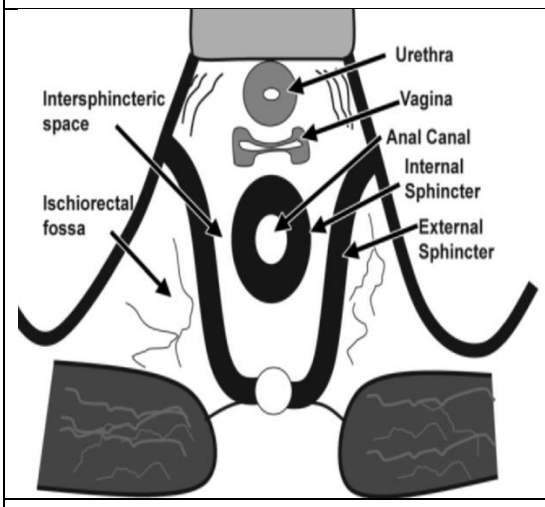
Causes:

- Idiopathic fistulas are generally believed to represent the chronic phase of intramuscular anal gland sepsis (ie, the cryptoglandular hypothesis).
- Crohn disease
- Tuberculosis
- Trauma during childbirth
- Pelvic infection
- Pelvic malignancy
- Radiation therapy.

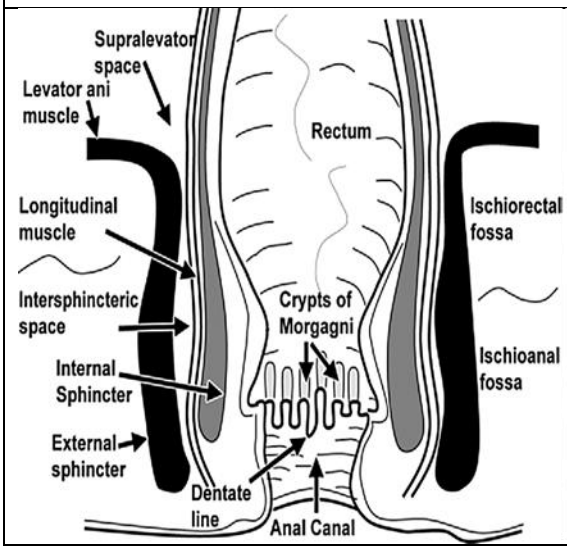
❖ Normal Male Anatomy

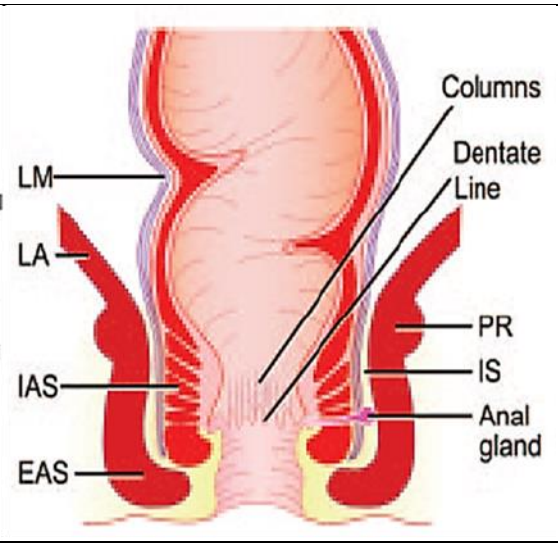


❖ Normal Female Anatomy



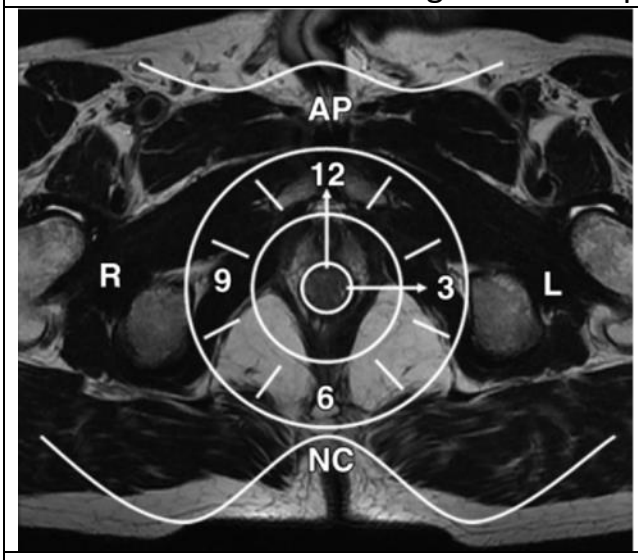
❖ Normal Coronal Anatomy

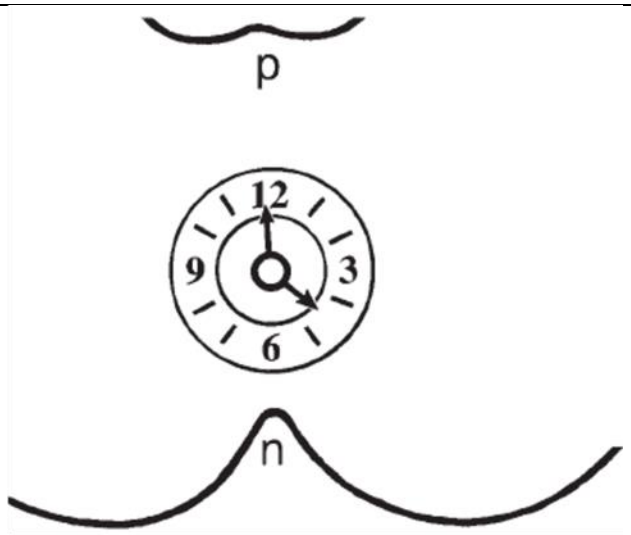




❖ Anal Clock

- The patient is in the lithotomy position.
- The anterior perineum (p) is at the 12 o'clock position
- The natal cleft (n) is at the 6 o'clock position
- 3 o'clock refers to the left lateral aspect
- 9 o'clock refers to the right lateral aspect of the anal canal.





❖ MRI Protocol

Suggested Protocol for MR Imaging of Anal Fistulas

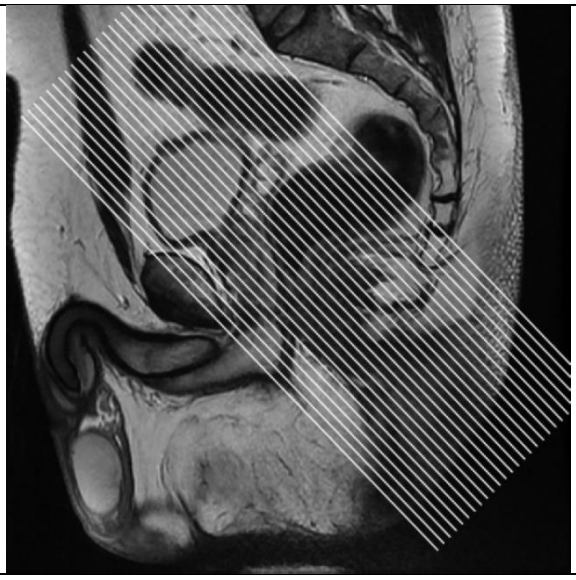
Parameters	T2W FSE	T1W FSE	T2W FSE	FS T1W FSE	FS T1W FSE
Imaging plane	Sagittal	Oblique axial	Oblique axial	Oblique axial	Oblique coronal
TR/TE (msec)	4500/110	450/12	4500/110	450/12	450/12
FOV (cm)	29 x 29	26 x 26	26 x 26	26 x 26	24 x 24
Section thickness (mm)	2.5	4.0	4.0	4.0	4.0
Intersection gap (mm)	0	0.8	0.8	0.8	0.8
Matrix	320 x 256	384 x 224	320 x 256	384 x 224	512 x 224
NSA	2	2	4	2	2

❖ Role of T2 WI

- Provide good contrast between:
  - Fluid in the track => hyperintense
  - Fibrous wall of the fistula => hypointense
- Allow adequate differentiation of the anatomic boundaries between the internal and external sphincters.
- **Active fistulous tracks** and extensions have high signal intensity on T2, while the sphincters and muscles have low signal intensity.
- **Chronic fistulous tracks or scars** appear as areas of low signal intensity on both T1- and T2.
- **Abscesses** have high signal intensity on T2-weighted images due to the presence of pus in the central cavity

❖ Role of T1+C FS:

- Active Fistulous tracks demonstrate intense enhancement,
- Fluid in the track remains hypointense.
- Abscesses demonstrate a central area of low signal intensity due to pus that is surrounded by intense ring enhancement.
- Chronic fistulas tracks and scar tissue do not enhance

Axial Oblique	Coronal Oblique
	

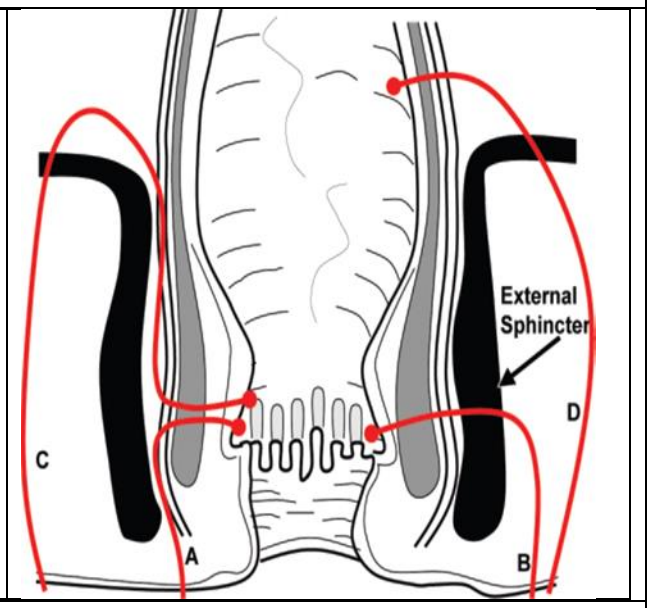
❖ Parks Classification

A = Intersphincteric

B = Transsphincteric

C = Suprasphincteric

D = Extrasphincteric



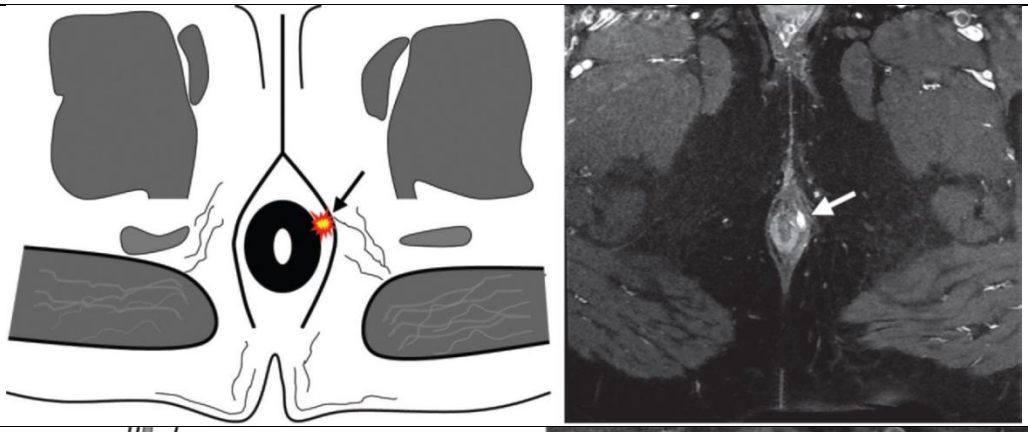
❖ St James's University Hospital Classification

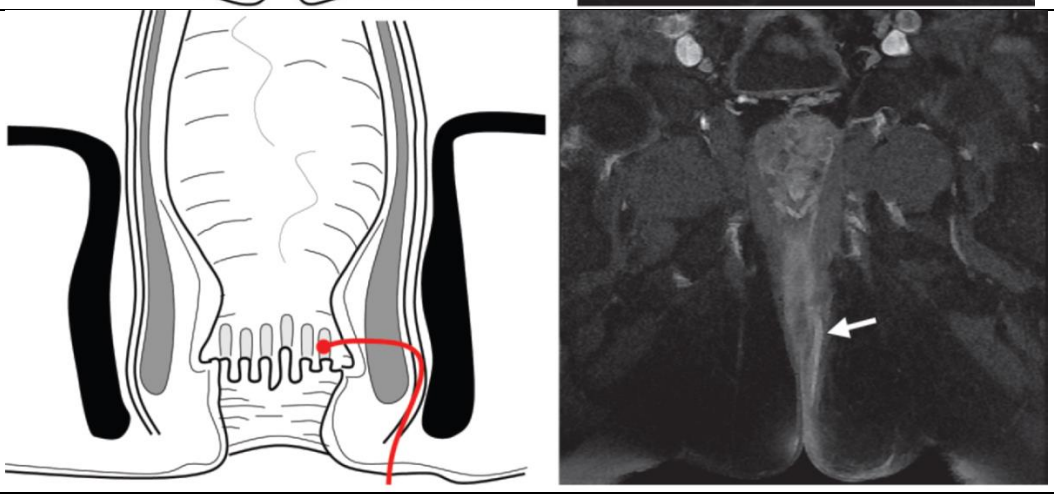
St James's University Hospital MR Imaging Classification of Perianal Fistulas

Grade	Description
0	Normal appearance
1	Simple linear intersphincteric fistula
2	Intersphincteric fistula with intersphincteric abscess or secondary fistulous track
3	Trans-sphincteric fistula
4	Trans-sphincteric fistula with abscess or secondary track within the ischioanal or ischiorectal fossa
5	Supralevator and translevator disease

❖ Grade 1

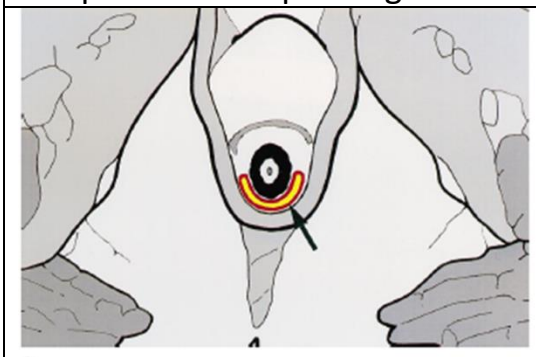
- Simple Linear Intersphincteric Fistula
- 45%
- No side brancheses
- No perianal collections
- Ischiorectal and ischioanal fossae are clear
- No ramification of the track within the sphincter complex.
- The enhancing track is seen in the plane between the sphincters and is entirely confined by the external sphincter.





❖ Grade 2

- Intersphincteric Fistula with Abscess or Secondary Track
- Are also bounded by the external sphincter.
- Secondary fistulous tracks may be of the horseshoe type, crossing the midline, or they may ramify in the ipsilateral intersphincteric plane.
- Even when there is abscess formation, this process is confined within the sphincter complex regardless of imaging plane or sequence.



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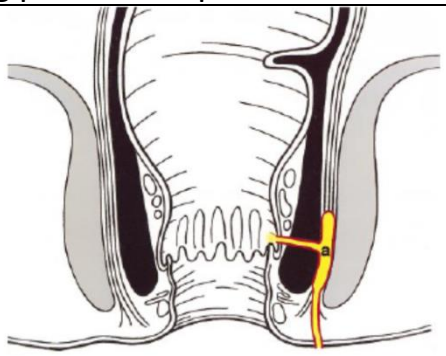

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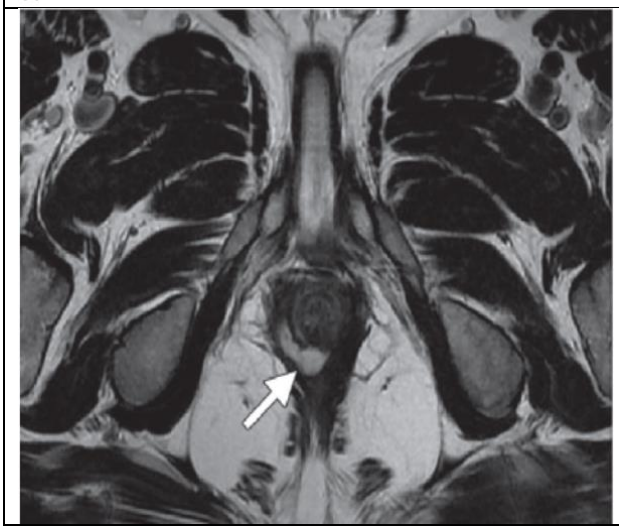
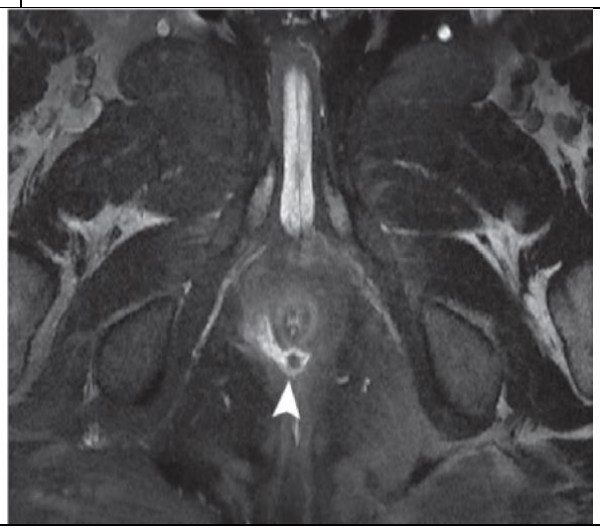
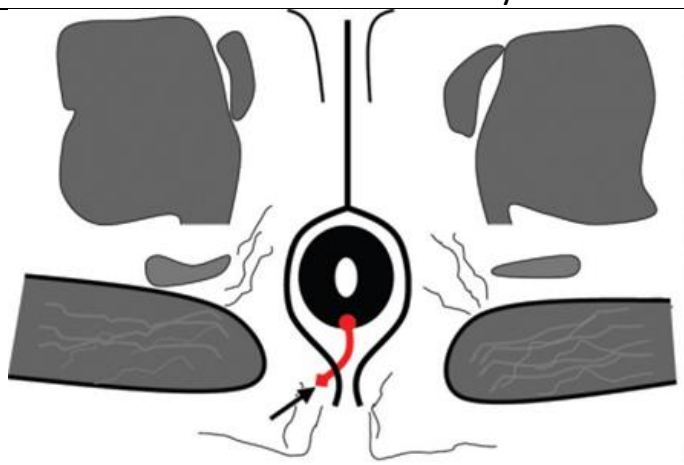
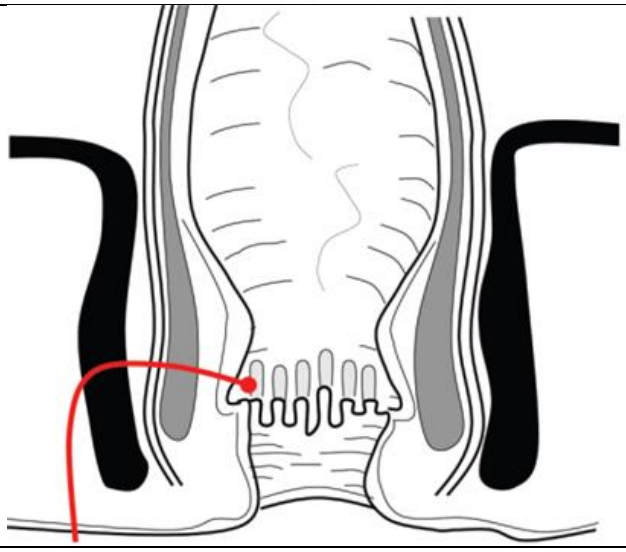




❖ Grade 3

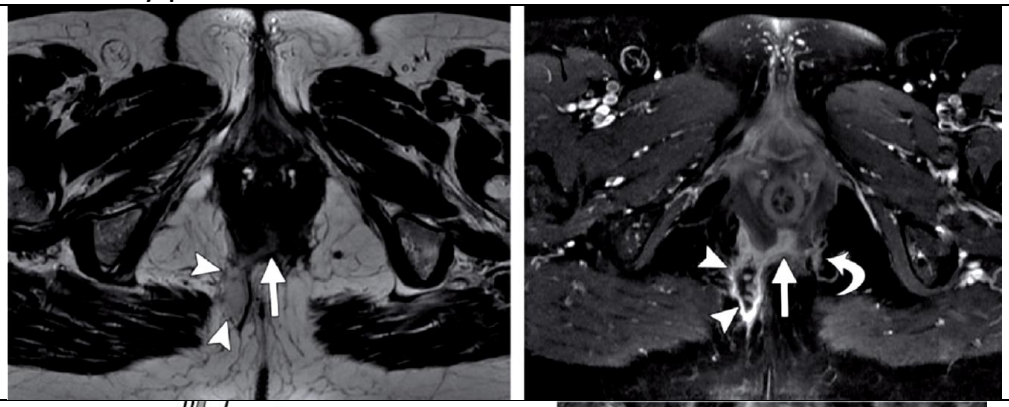
- Trans-sphincteric fistula pierces through both layers of the sphincter complex and then arcs down to the skin through the ischiorectal and ischioanal fossae.
- Trans-sphincteric fistula may disrupt the normal fat of the ischiorectal and ischioanal fossae with secondary edema and hyperemia.

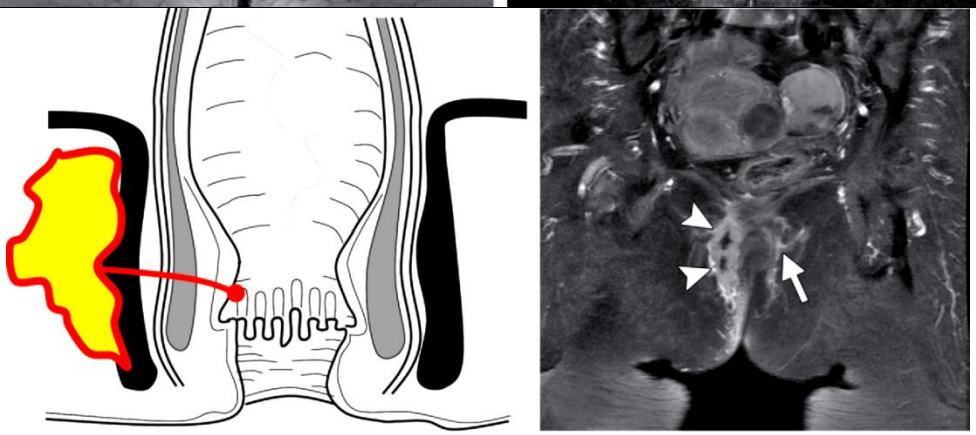


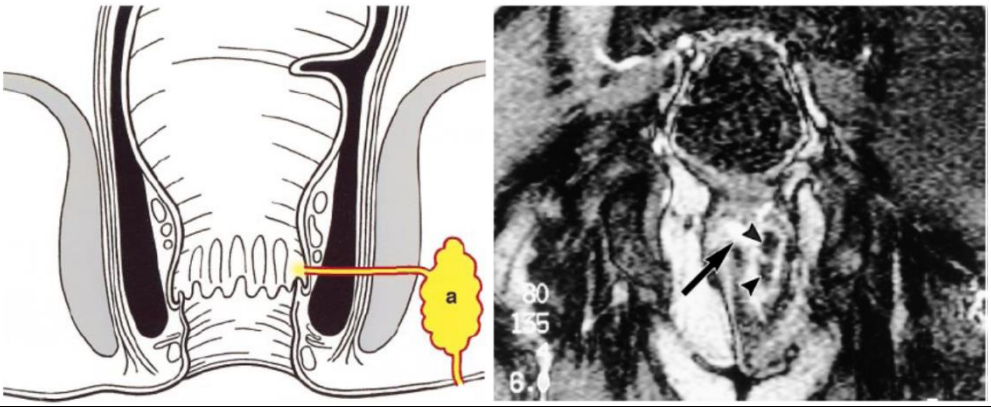


❖ Grade 4

- Trans-sphincteric Fistula with Abscess or Secondary Track within the Ischiorectal Fossa
- can be complicated by sepsis in the ischiorectal or ischioanal fossa
- An abscess may manifest as an expansion along the primary track or as a structure distorting or filling the ischiorectal fossa. It has a central focus of low-signal-intensity pus

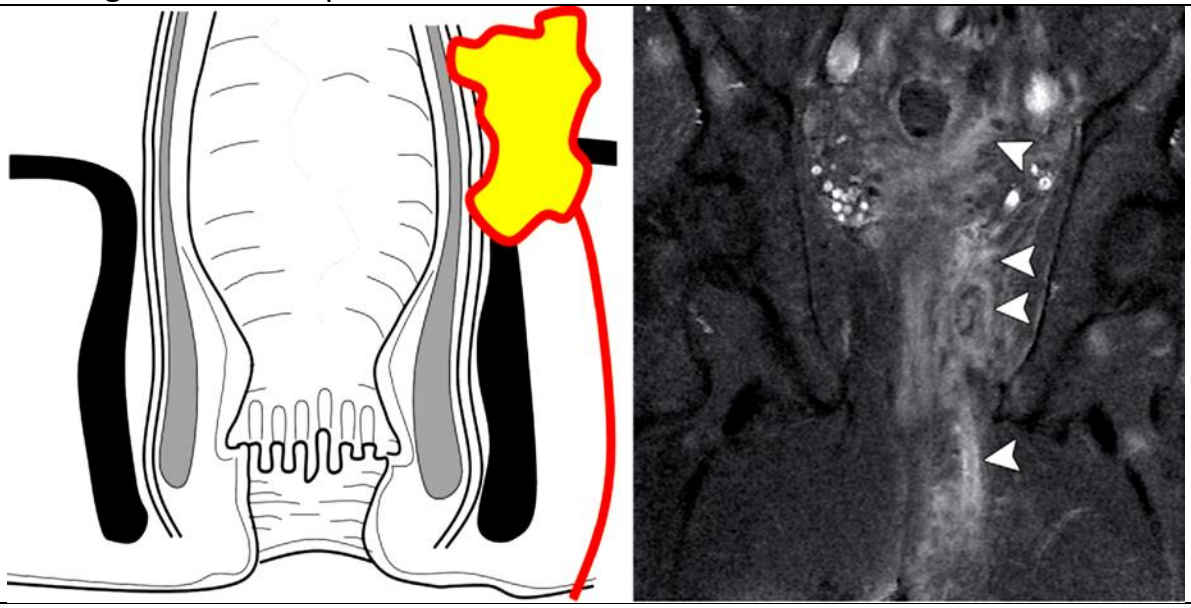






❖ Grade 5

- Supra-levator and Trans-levator Disease
- In rare cases, perianal fistulous disease extends above the insertion of the levator ani muscle. extend upward in the intersphincteric plane and over the top of the levator ani to pierce downward through the ischiorectal fossa.
- Extrasphincteric fistulas reflect extension of primary pelvic disease down through the levator plate.



Rectal Cancer

- Rectal cancer is a common disease with a high rate of mortality in Western countries.
- M>F
- 95%–97% of rectal cancers are adenocarcinomas

Risk factors:

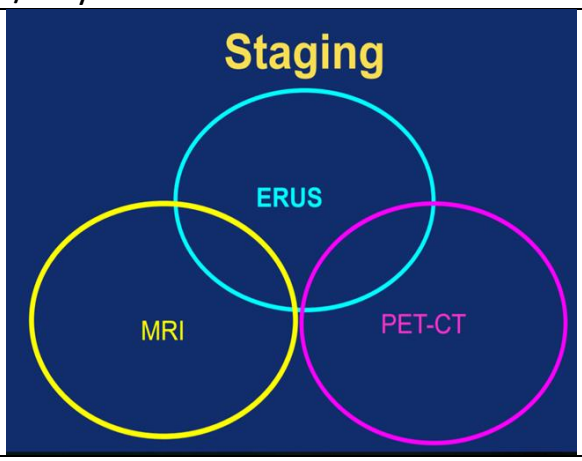
- Age >50 y
- Obesity
- Long-term smoking
- Hereditary syndromes, including polyposis, nonpolyposis, and hamartomatous disorders

Age of start Screening programs:

- ✓ No family history > 50y
- ✓ +ve family history >40y
- ✓ Ulcerative colitis (UC): 7-8y after pancolitis
- ✓ FAP: start from puberty.

Screening Tests:

- ✓ Fecal occult blood in Stoll annualy.
- ✓ Double contrast Ba enema
- ✓ CT Colonography + Virtual Colonoscopy
- ✓ Sigmoidoscopy / 5y.
- ✓ Colonoscopy / 10y.



TNM Staging

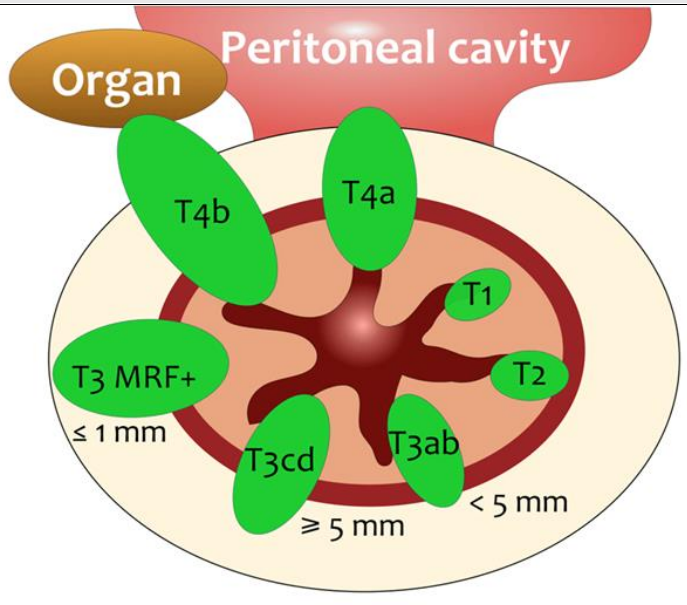
T-staging

T1 Tumor grows through muscularis mucosa and extend to submucosa
T2 Tumors grows through submucosa and extends to muscularis propia.
T3 Tumors grow through the bowel wall and infiltrate the mesorectal fat.

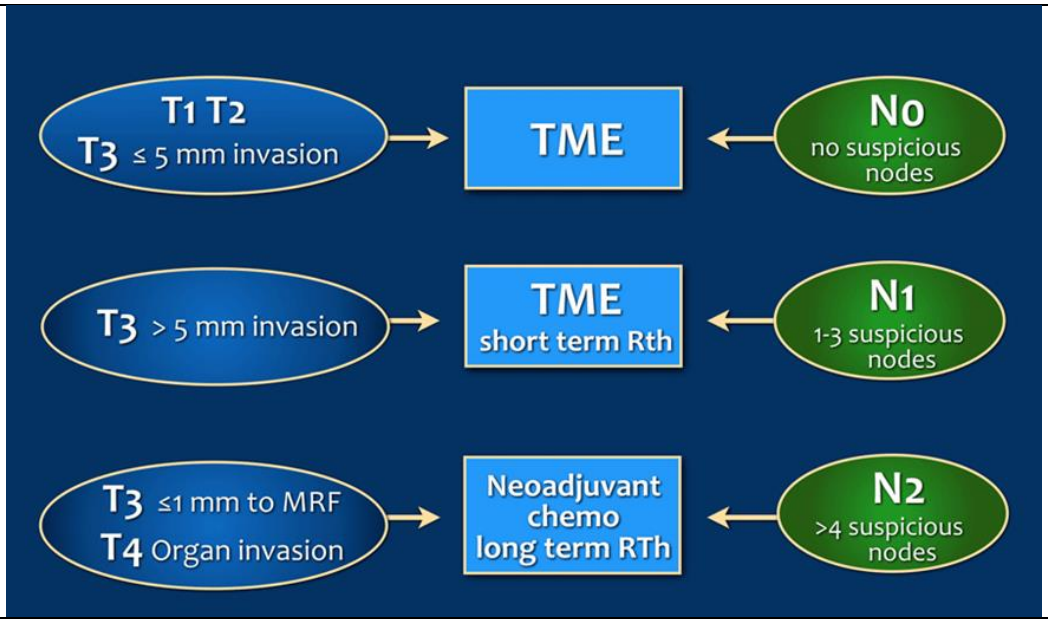
- T3a < 1mm extension beyond muscularis propria
- T3b 1-5 mm extension beyond muscularis propria
- T3c 5-15 mm extension beyond muscularis propria
- T3d > 15 mm extension beyond muscularis propria
- T3 MRF+ tumor within 1mm of MRF
- T3 MRF- no tumor within 1 mm of MRF

T4a Tumor penetrates visceral peritoneum
T4b Tumor adherent or invades other organs

Node	
Nx	Nodal staging is not possible because of incomplete information
N0	No cancer in regional lymph nodes
N1a	Tumor in one regional lymph node
N1b	Tumor in two or three regional nodes
N1c	Tumor deposits in the subserosa, mesentery, or nonperitonealized pericolic or perirectal tissues without regional nodal metastasis
N2a	Tumor in four to six regional nodes
N2b	Tumor in seven or more regional nodes
Metastases	
M0	No distant spread
M1a	Tumor is confined to one distant organ or site (eg, liver, lung, ovary, nonregional node)
M1b	Tumor spread to more than one organ or site or the peritoneum

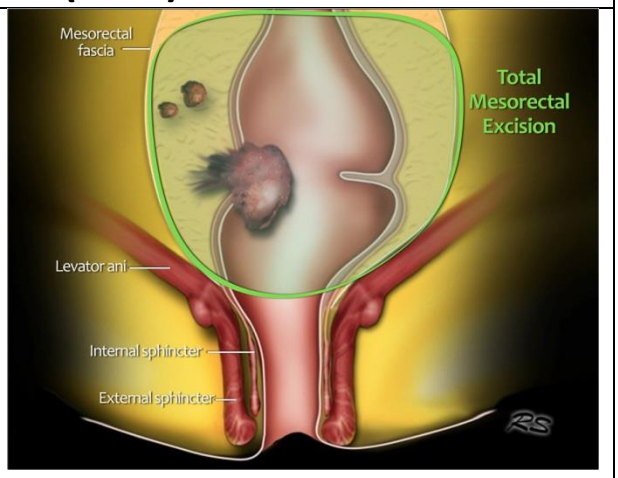


❖ Treatment Planning

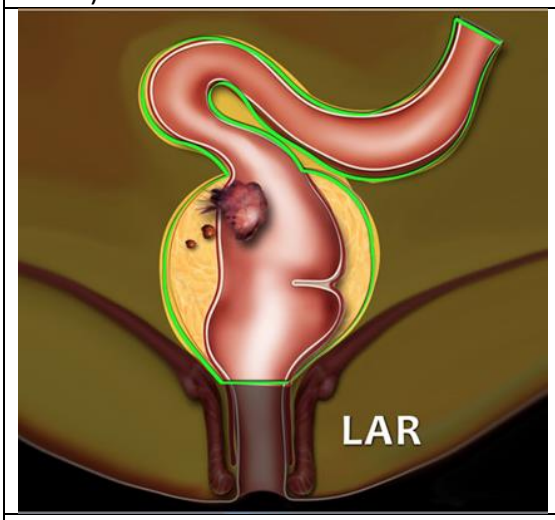
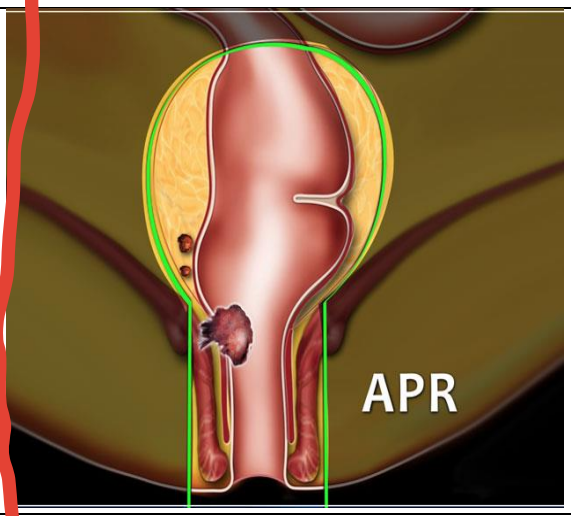
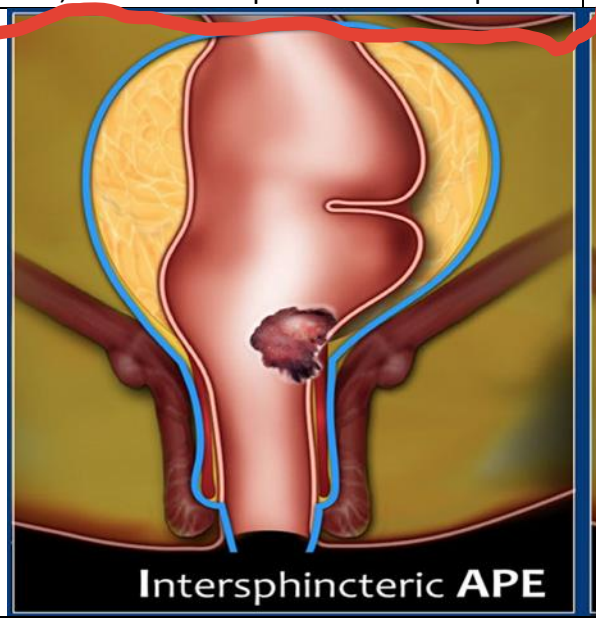
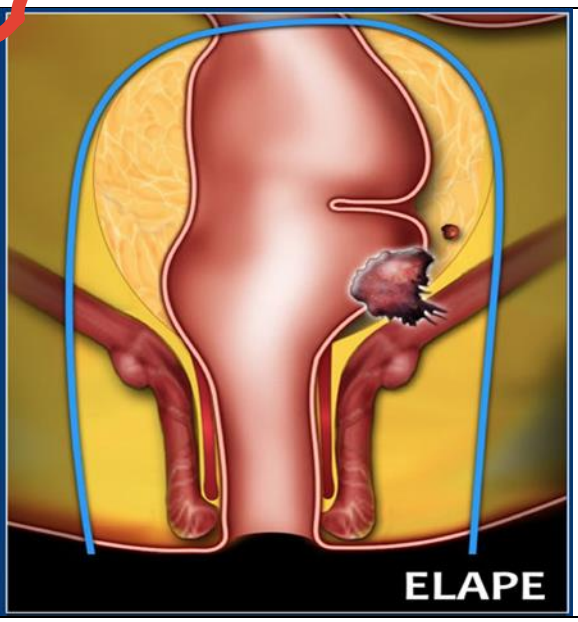


❖ Total Mesorectal Excision (TME):

- In the past decade, the increasingly widespread adoption of TME has resulted in a dramatic decline in the prevalence of local recurrence from 38% to less than 10%
- TME is a surgical technique that entails en bloc resection of the primary tumor and the mesorectum by means of dissection along the mesorectal fascial plane (MRF) or the circumferential resection margin (CRM)

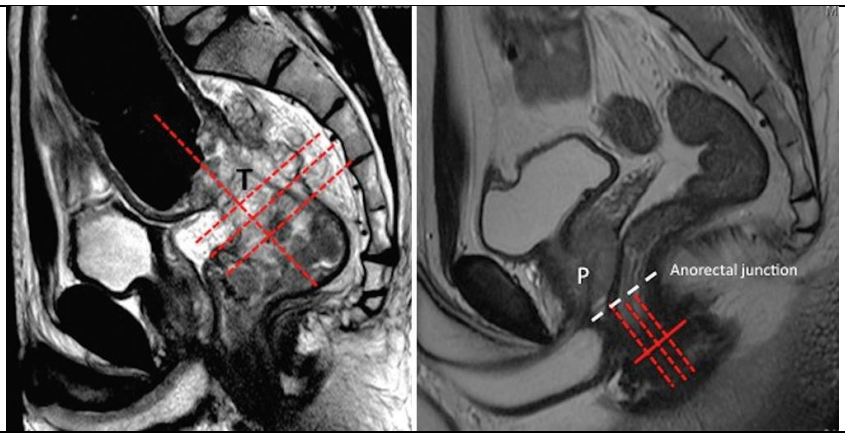


- The presence of a tumor or malignant node within 1 mm of the CRM remains an important predisposing factor for local recurrence.
- Consequently, reliable preoperative imaging evaluation is vital to surgical planning.

Low Anterior Resection (LAR)	**Abdomino-Perineal-Resection (APR)**
TME procedure in **high rectal cancer**. The following structures are removed: Rectum - mesorectum - mesorectal fascia (TME) Sigmoid colon (or part of the sigmoid colon)	Low rectal tumours that invade the anal canal or levator ani. Two incisions are made: Abdominal - to remove the rectum and mesorectum (TME) Perineal - to remove the anal canal
	
The Intersphincteric abdomino-perineal excision is variation to the standard APR. When the intersphincteric plane is tumor-free, the external sphincter can be spared	The extralevator abdomino-perineal excision is variation to standard APR. The ELAPE is a more extensive procedure which includes the levator muscles.
	

❖MRI Protocol:

- High-resolution MRI (HR-MRI)
- Phased array external coil
- Endorectal coil (ER-MRI) is not recommended
- Sagittal T2 sequence first and plan the axial and coronal small FOV sequences orthogonal to the tumor
- Axial T1 and T2 with large FOV
- Axial and Coronal T2 and T2 FS with small FOV and thin sections (3mm)
- DWI
- Contrast has no added value



❖MRI Assessment & Report:

1) Tumor location: Longitudinal and circumferential
2) Tumor distance form anal verge and anorectal junction
3) Tumor length
4) Tumor staging within wall
5) Depth of invasion outside the muscularis propria
6) Relationship to the mesorectal fascia (MRF) / circumferential resection margin (CRM)
7) Relationship to visceral peritoneum
8) Relationship to anal sphincter
9) Relationship to pelvic sidewall.
10) Relationship to adjacent organs
11) Extra-mural Vascular invasion
12) Mesorectal LNs
13) Extra-mesorectal LNs

1) Longitudinal Tumor Location

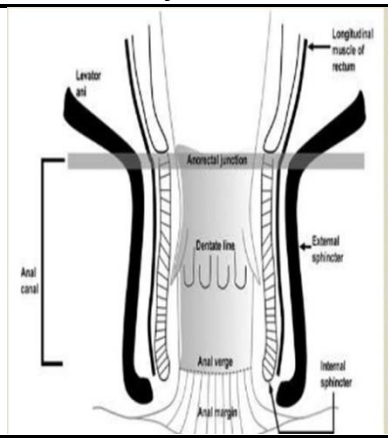
a) Distance from lower border of tumor to Anal Verge (AV):

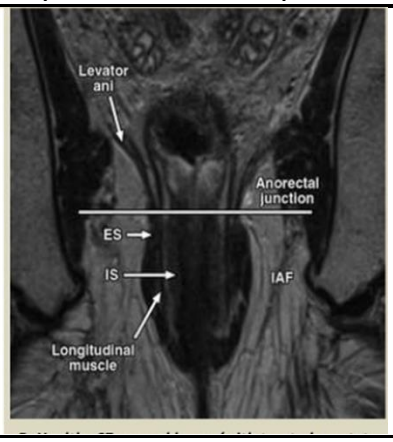
- The anal verge refers to the mucocutaneous junction of the anus and is located at the lower margin of subcutaneous external sphincter muscle.
- Measured in sagittal plane along approximate luminal center of rectum and anus
- Distance from lower border of tumor to anal verge (AV) divided into:

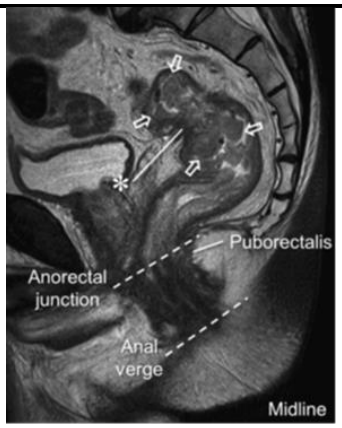
Low rectal cancer: **0- 5 cm from AV**	**Mid rectal cancer:** **5-10cm form AV**	**High rectal cancer** **10-15 cm from AV**

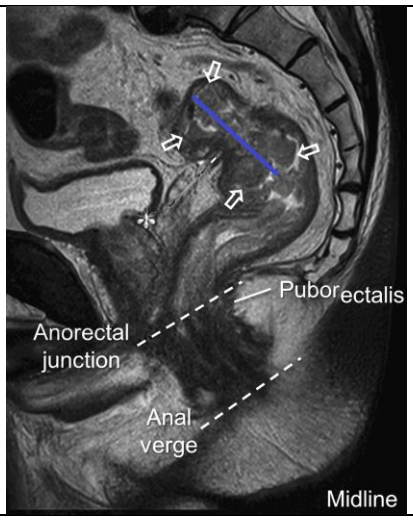
b) Distance from lower border of tumor to Anorectal Junction

Anaorectal junction is the top border of the puborectalis muscle







2) Circumferential Tumor Location:	3) Longitudinal Tumor Length
➢ Can be described as lateral, anterior or posterior ➢ or in a clockwise manner, i.e. from 1 o' clock to 8 o' clock.	Craniocaudal tumor extent along the long axis of the colorectum
	

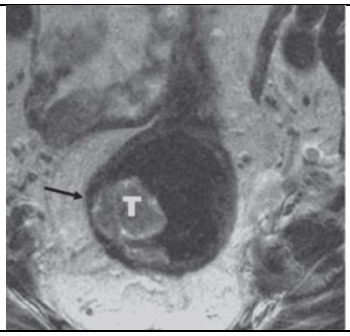
4) T-Staging

based on the definition of rectal wall anatomy on high-resolution T2 and the relationship of the tumor to the submucosa and muscularis propria

- **Stage T1:** replacement of the high signal of the submucosal layer by abnormal intermediate signal not extending into the muscle coat
- **Stage T2:** abnormal intermediate SI within low signal of the muscularis propria
- **Stage T3:** broad-based bulge or nodular projection of intermediate SI projecting beyond outer muscle coat

Stage T1:

A polypoid tumor (T) on the right lateral aspect of the rectal wall protruding into the rectal lumen.
The muscular layer (arrow), appears thinned and spared.

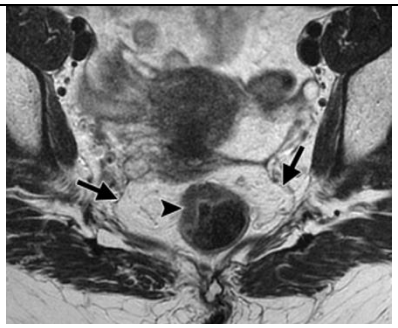


Stage T2

- An ulcerated tumor (arrowhead) along the posterior rectal wall.
- The muscularis propria is seen as a thin hypointense line (white arrow).
- Along the posterior right lateral wall, tumor is seen to focally penetrate into the muscularis propria (black arrow) but not beyond it

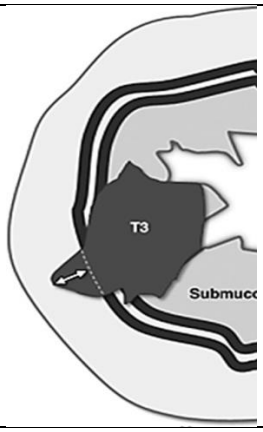
Stage T3

- An ulcerated lesion (arrowhead) along the anterior aspect of the rectum
- Tumor extends beyond the muscularis propria into the mesorectal fat.
- The mesorectal fascia is seen as a thin hypointense line (arrows) surrounding the mesorectal fat.

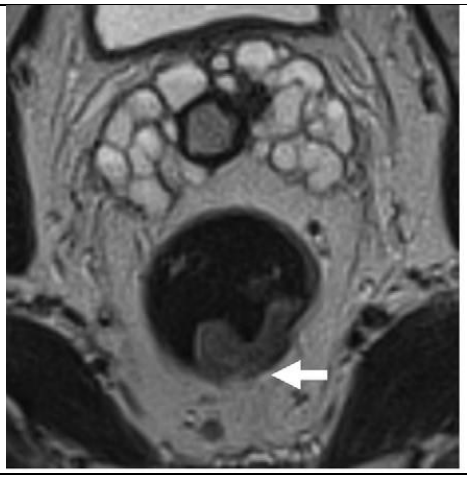


5) Depth of Tumor Invasion Outside Muscularis Propria

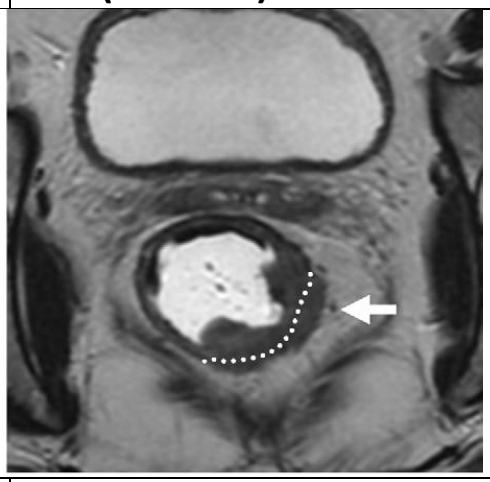
- 80% of rectal tumors are stage T3 that form a heterogeneous group.
- 5-year survival rates varying based on the depth of tumor invasion outside the muscularis propria.
  - < 5mm => Early stage => High survival rate (85%)
  - > 5mm => Advanced stage => Low survival rate (45%)



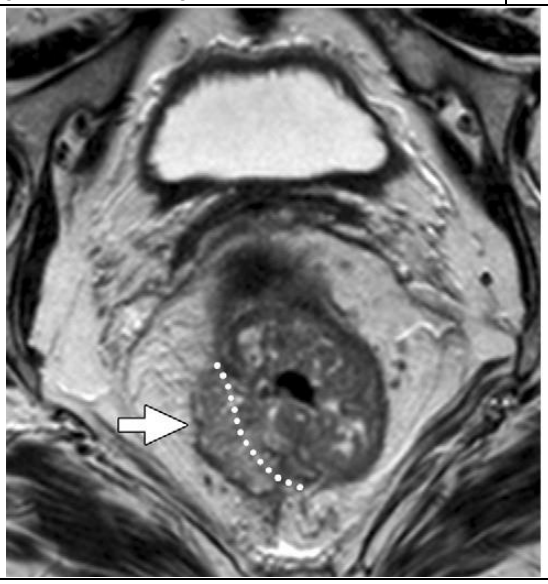
T3a (1 mm)



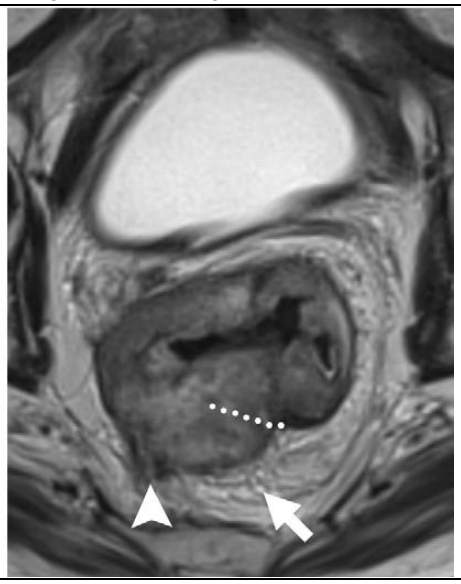
T3b (1–5 mm)



T3c (5–15 mm)



T3d (> 15 mm)



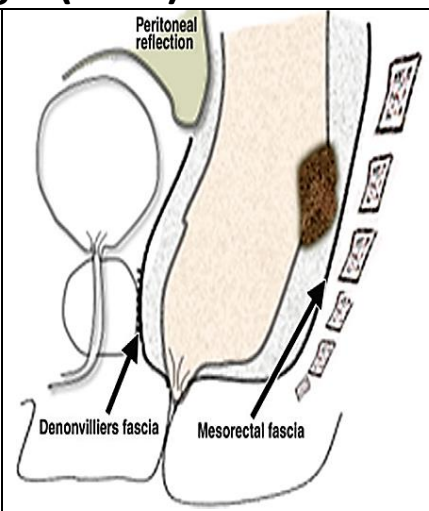
6) Relationship of Tumor to Mesorectal Fascia (MRF)/ Circumferential Resection Margin (CRM)

Mesorectal fascia is visceral layer of the endopelvic fascia,

Laterally: encircles the rectum and the mesorectal fat, nodes, and lymphatic vessels

Posteriorly: Runs along the anterior aspect of the sacrum, where it fuses with the presacral fascia.

Anteriorly in males: it forms a dense band of connective tissue posterior to the seminal vesicle and prostate gland called the Denonvilliers fascia



Circumferential Resection Margin (CRM):

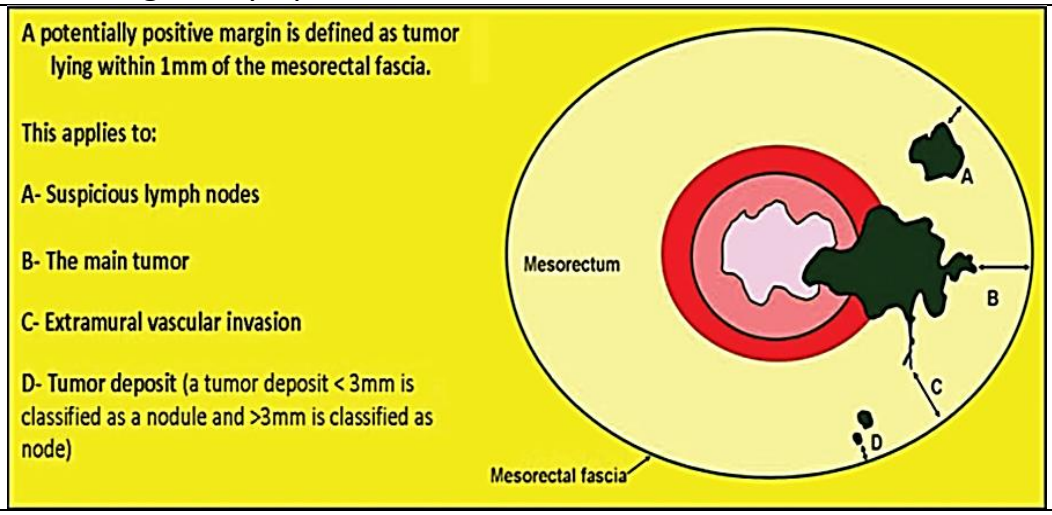
The relationship of the tumor to the mesorectal fascia is critical for surgical planning

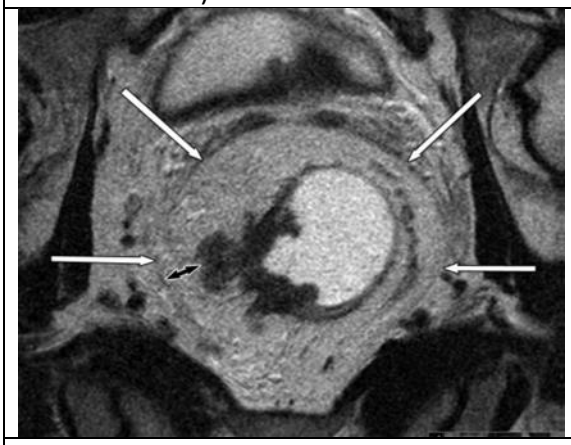
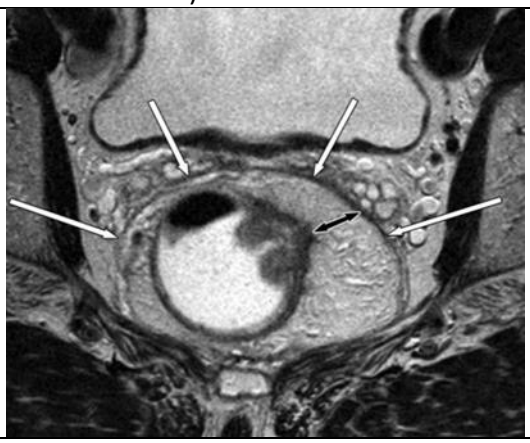
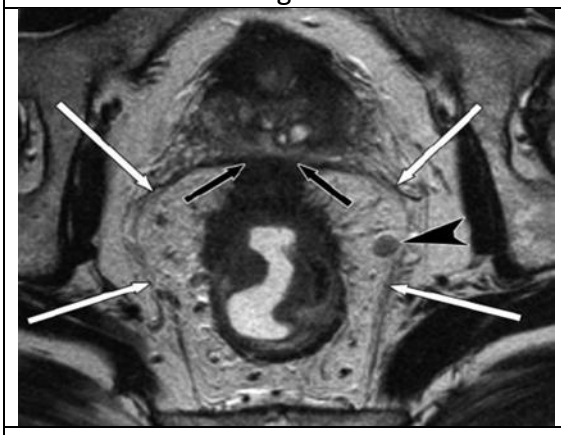
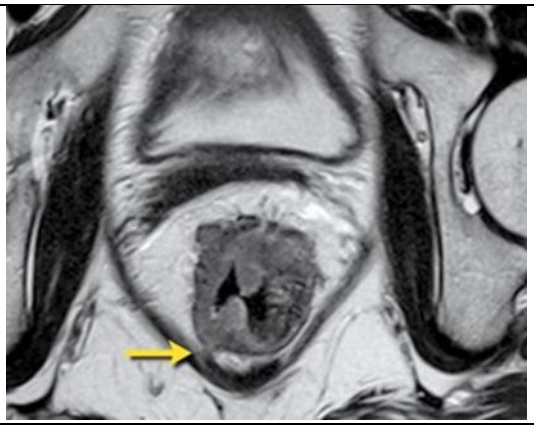
T3 MRF/CRM—: > 1 mm between the tumor and the CRM has been shown to correlate with a decrease in local recurrence .

T3 MRF/CRM+: ≤ 1 mm between the tumor and the CRM is indicative of CRM involvement.

The measured distance is the distance to the mesorectal fascia from either:

- The tumor margin
- A tumor deposit in the mesorectum (<3mm)
- Tumor thrombus within a vessel
- A malignant lymph node.



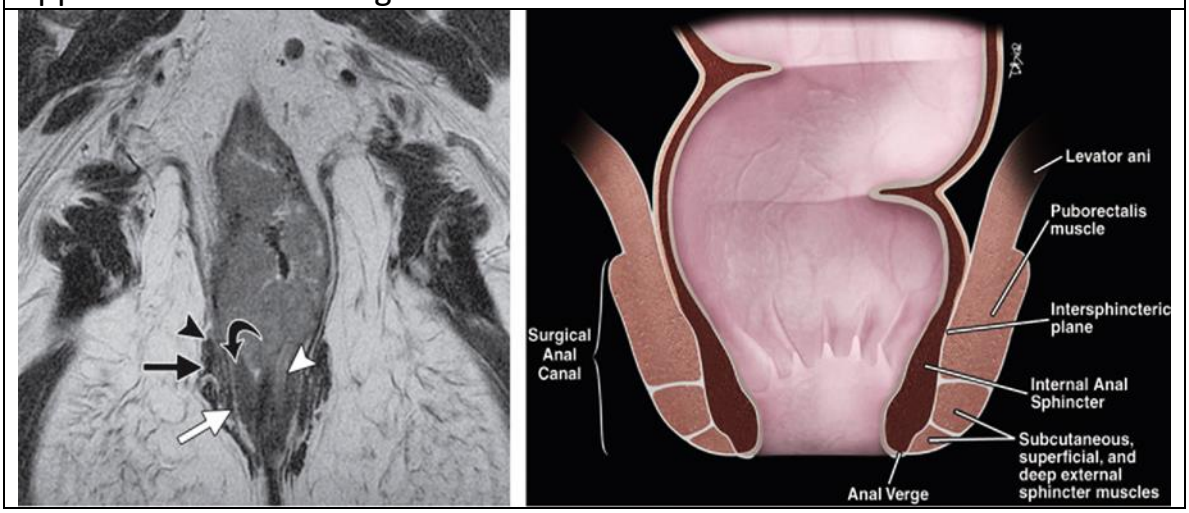
Distance to the mesorectal fascia (double-headed arrow) of 5 mm.	Distance to the mesorectal fascia (double-headed arrow) of 12 mm.
	
The tumor has large extramural infiltrations involving mesorectal fascia.	Low rectal tumor with involved mesorectal fascia
	

7) Relationship of Tumor to Anal Sphincter
⇨ Stage T3

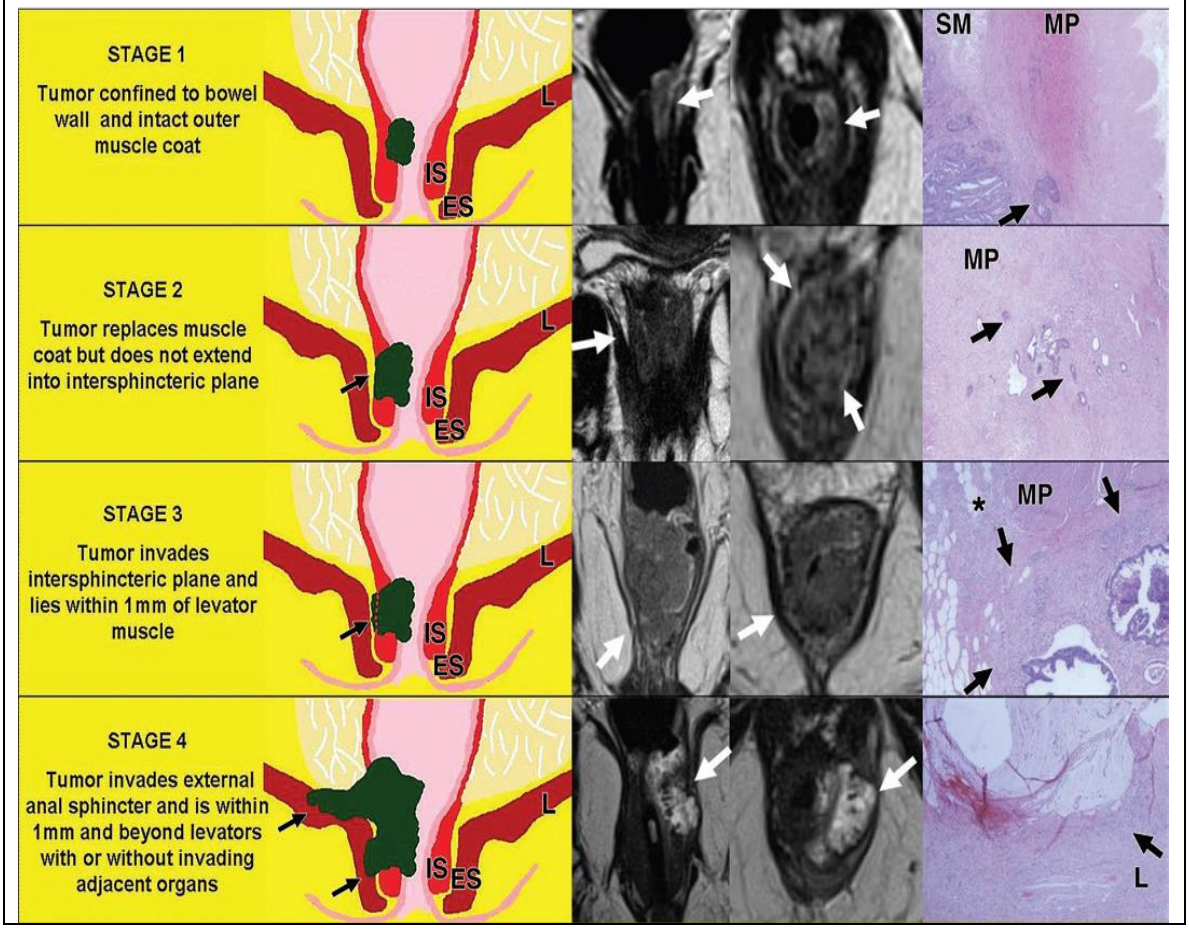
- Internal anal sphincter is a continuation of the circular muscle layer of the rectum,
- External sphincter complex is composed of the most inferior part of the levator ani muscle, the puborectalis sling, and the external sphincter muscles (subcutaneous, superficial and deep).
- The upper border of the puborectalis sling forms the upper edge of the surgical anal canal.

- Evaluation of the relationship of the tumor to the upper margin of the puborectalis sling assists in the presurgical determination of whether sphincter-sparing resection is feasible.
- This relationship is best evaluated on coronal images.

Coronal high-resolution T2-weighted MR image shows a low rectal tumor involving the left side of the internal anal sphincter (white arrowhead). The right side of the internal sphincter (curved black arrow) is separated from the puborectalis muscle (straight black arrow) by the thin, hyperintense intersphincteric plane (white arrow).
The upper margin of the puborectalis muscle (black arrowhead) defines the upper border of the surgical anal canal.

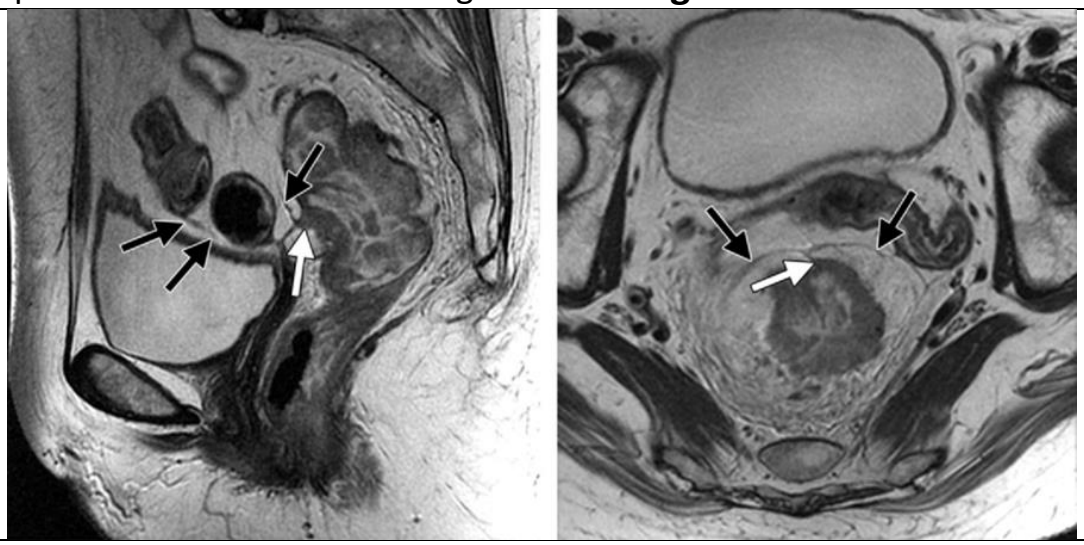


Low rectal cancer staging by Shihab et al



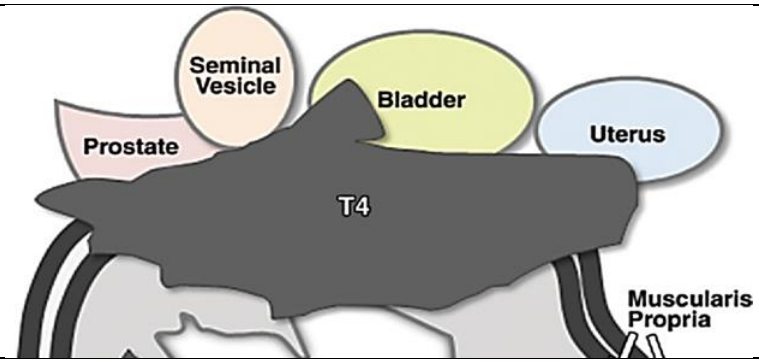
8) Relationship of Tumor to Peritoneal Reflection ⇨ Stage T4a

- The peritoneum reflects off the superior aspect of the urinary bladder and onto the anterior aspect of the rectum, forming the rectovesical pouch .
- On sagittal T2, the peritoneum is seen as a hypointense linear structure .
- On axial images, it has a V shape and attaches onto the anterior aspect of the rectum
- The relationship between tumor and the peritoneal reflection is important in staging, since rectal tumors with invasion through the peritoneal reflection are categorized as **stage T4a lesions**

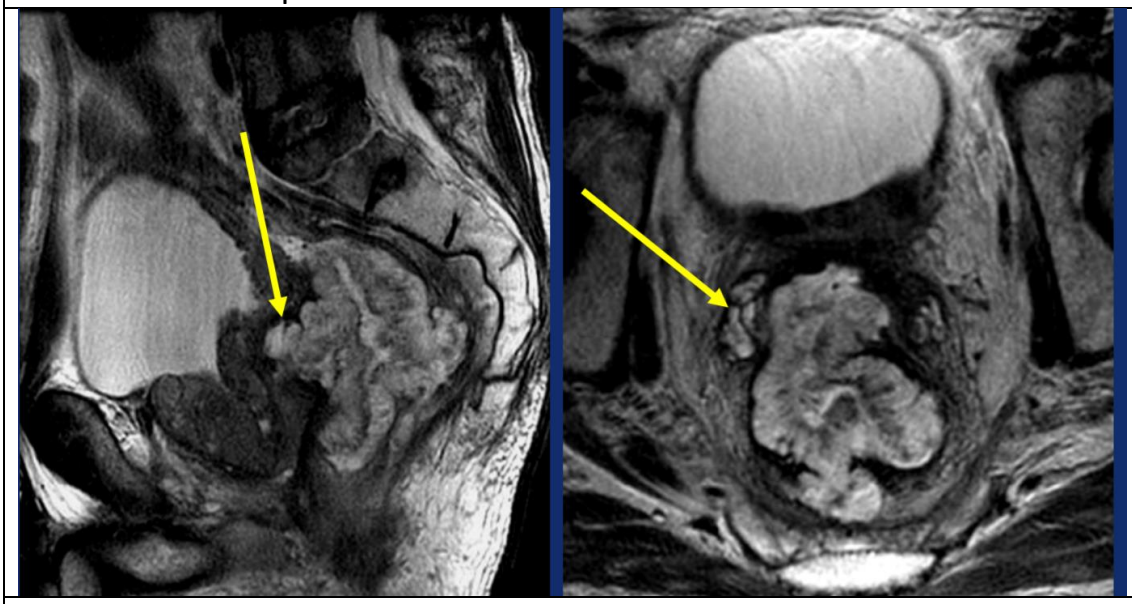


9) Relationship of Tumor to Pelvic Organs ⇨ Stage T4b

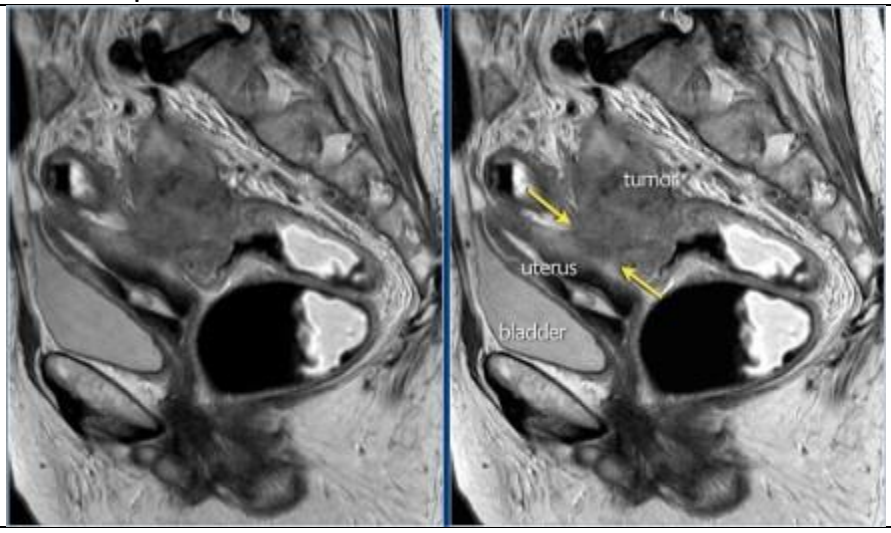
- The structures most commonly involved by primary rectal cancer are the uterus, vagina, prostate gland, and seminal vesicles.
- The assessment of tumor abutment of the presacral fascia and involvement of sacral nerve roots is also important for surgical planning.
- Tumor extension into the proximal sacrum or nerve root involvement above the S2 vertebral level may render the tumor unresectable.



Tumor extend to prostate



Tumor extend to posterior uterine wall



10) Relationship of Tumor to Pelvic Sidewall

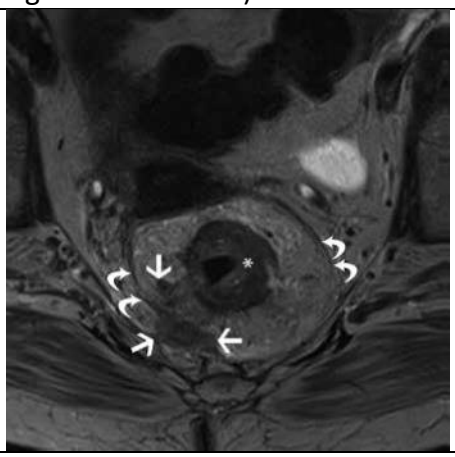
⇨ Stage T4b

a) Lateral pelvic side wall include :

- Common, external, and internal iliac vessels
- Pyriformis muscle and internal obturator muscle.
- The region of the sciatic foramen.
- These structures are covered by the endopelvic fascia, also called the parietal layer of the pelvic fascia
- At the level of the midrectum, the visceral and parietal layers of the endopelvic fascia can generally be identified as separate and distinct entities on MR images.
- At the level of the lower and upper rectum, these structures may be indistinguishable.
- In these regions, tumor involvement of the mesorectal fascia may equate to pelvic sidewall involvement.

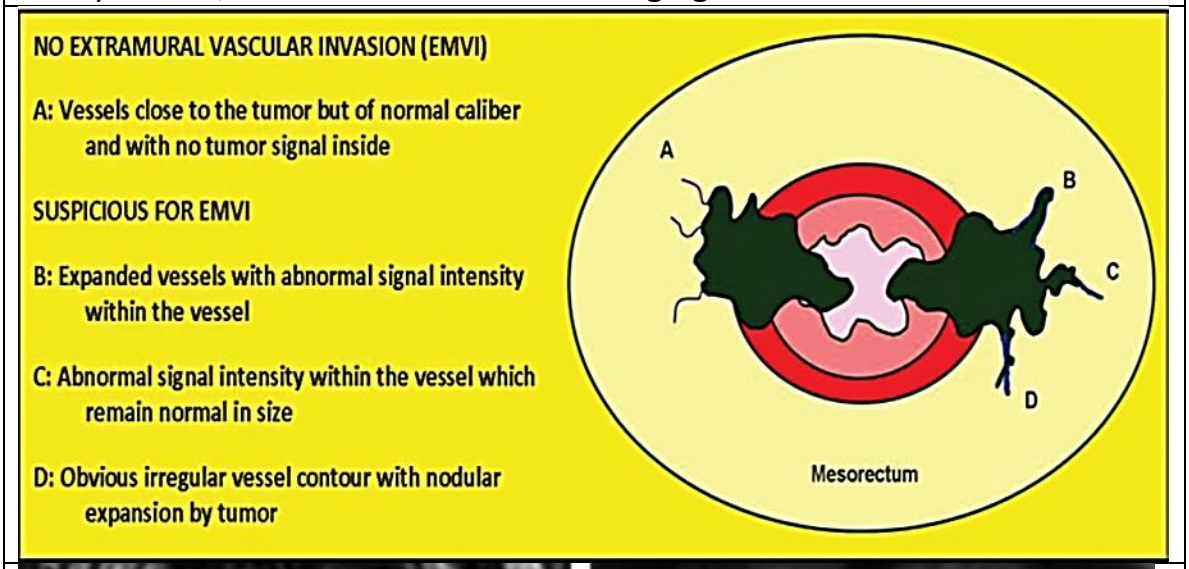
b) Presacral Region:

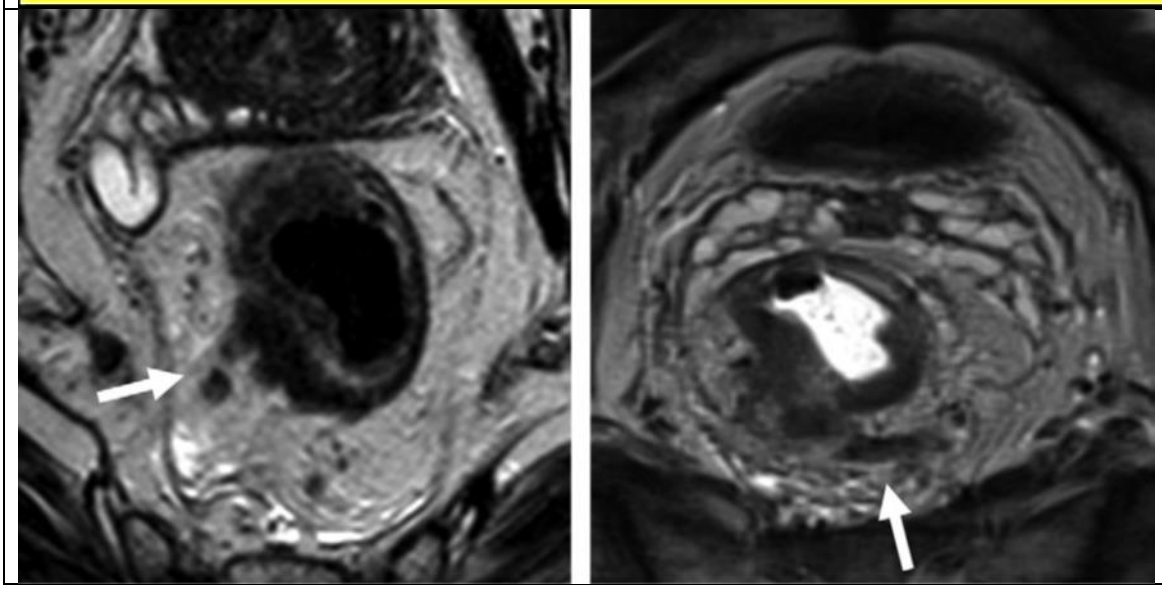
- Presacral fascia: which is a continuation of the parietal pelvic fascia that covers the sacral nerve roots and sacral veins.
- Mesorectal fascia: runs along the anterior aspect of the presacral fascia and is separated from it by a potential retrorectal space, which forms the plane of dissection in TME.

High rectal tumor (black arrow) infiltrating through the posterior rectal wall and involving mesorectal fascia (arrowheads), which is separated from the presacral fascia (white arrows in a) by retrorectal space.	Circumferential tumor (asterisk) with tumor deposits (arrows) within the mesorectum, involving the mesorectal fascia (curved arrows), and extending to the right posterolateral pelvic wall (far right lateral arrow)
	

11) Extra-mural Venous Invasion (EMVI)

- Although vascular invasion does not affect treatment decision making and is assessed at pathologic analysis, it has prognostic significance and, if possible, should be evaluated at imaging.


NO EXTRAMURAL VASCULAR INVASION (EMVI)
A: Vessels close to the tumor but of normal caliber and with no tumor signal inside
SUSPICIOUS FOR EMVI
B: Expanded vessels with abnormal signal intensity within the vessel
C: Abnormal signal intensity within the vessel which remain normal in size
D: Obvious irregular vessel contour with nodular expansion by tumor
A
B
C
D
Mesorectum

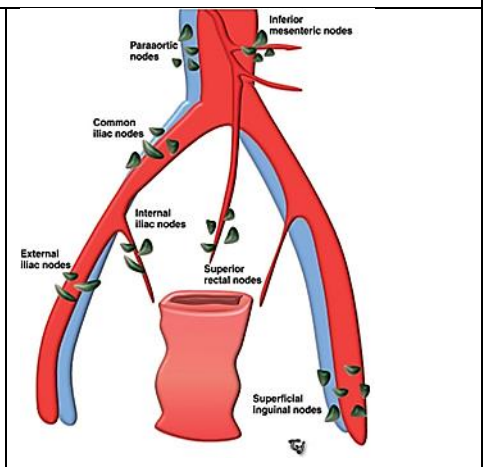


12) Assessment of LNS Involvement

Locoregional LNs:

- Mesorectal
- Inferior mesenteric
- Internal iliac
- Superior rectal, middle rectal, and inferior rectal
- Lateral sacral, presacral
- Sacral promontory (Gerota's)

Lymph nodes outside of these areas are considered metastatic disease (M1).



❖ Criteria of Malignant LNs:

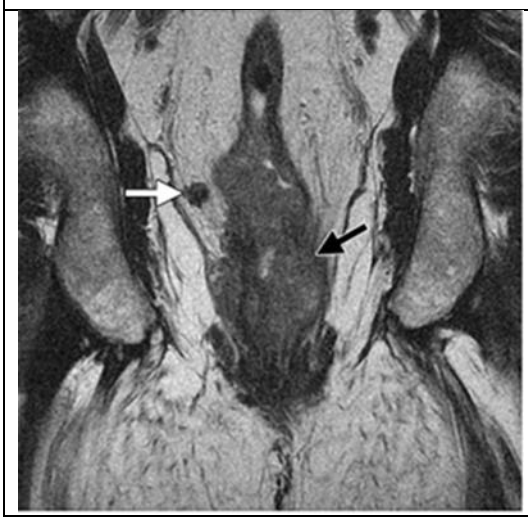
1) Nodal size:

- It is well established that nodal size is of limited value in assessing for the presence of metastasis.
- The most frequently used size criterion for distinguishing malignant from nonmalignant nodes (ie, 5 mm) has a sensitivity of 68% , a specificity of 78%
- The limited accuracy of nodal size is likely related to the fact that 30%–50% of metastases in rectal cancer occur in nodes < 5 mm

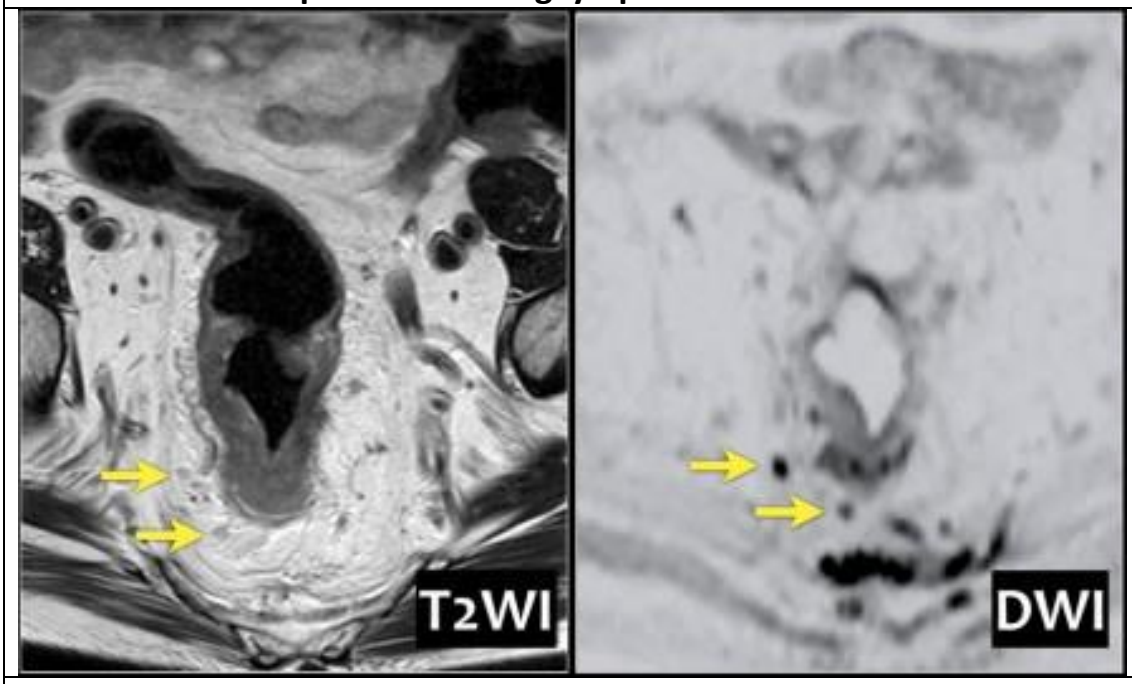
2) **Nodal shape:** Oval => Rounded

3) **Nodal margins:** irregular or spiculated nodal margins

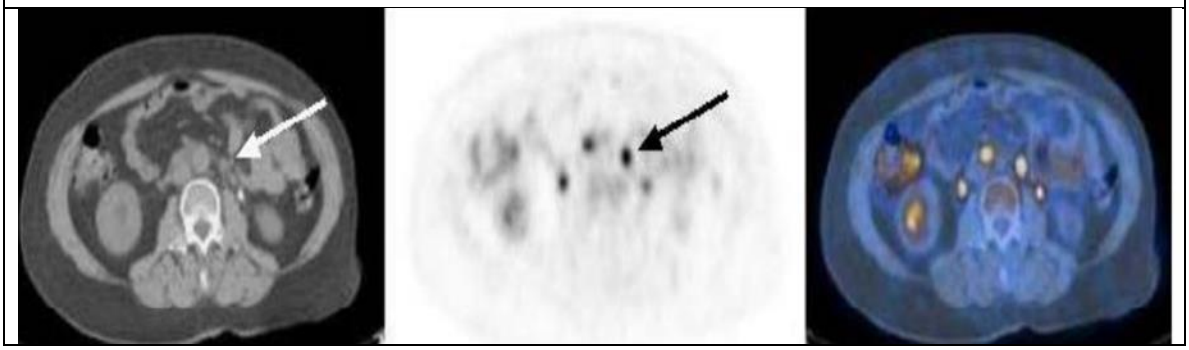
4) **Internal nodal characteristics** : heterogeneous signal intensity

Mesorectal LN	**Extra-mesorectal Left Pelvic sidewall LN**
	

❖ **DWI can be helpful in detecting lymph nodes**



❖ **PETCT identification of subcentimetric metastatic LNs**



Anal Canal and Perianal Tumors

Table 2: World Health Organization Classification of Anal Canal Tumors

Tumor Type
Intraepithelial neoplasia
Anal intraepithelial neoplasia
Epithelial tumors
SCC
Adenocarcinoma
Mucinous adenocarcinoma
Small cell carcinoma
Undifferentiated carcinoma
Nonepithelial tumors
Leiomyoma
Gastrointestinal stromal tumor
Myofibroma
Carcinoid tumors
Melanoma
Secondary tumors
Direct extension from adjacent organs: rectal carcinoma, cervical carcinoma, and prostate carcinoma

1) SCC of Anal Canal

- Most common type of anal canal cancer
- 80%–85% of all anal canal cancers

Risk factors:

- HIV infection
- Homosexual men with HIV infection had double the risk for developing anal cancer compared with HIV-negative homosexual men.
- Immunosuppressed patients after transplantation.
- HPV infection
- Cigarette smoking
- Multiple sexual partners
- History of previous or current intraepithelial neoplasia of the cervix and vulva

Imaging findings:

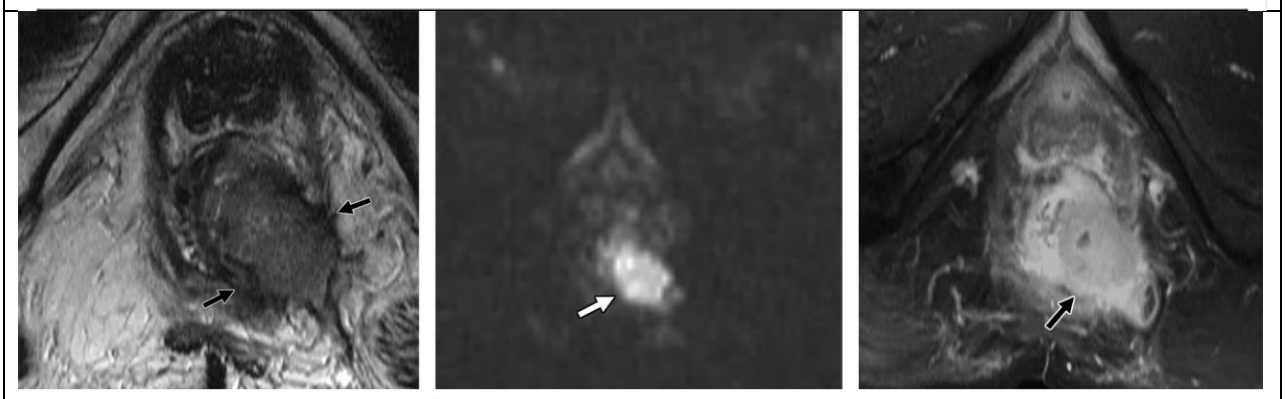
- Lobulated intraluminal or infiltrative mass
- Tendency to spread circumferentially.
- T1: isointense to hypointense
- T2: isointense to hyperintense
- T1+C: enhances

Regional lymph nodes:

- Perirectal LNs
- Internal iliac LNs
- Inguinal LNs

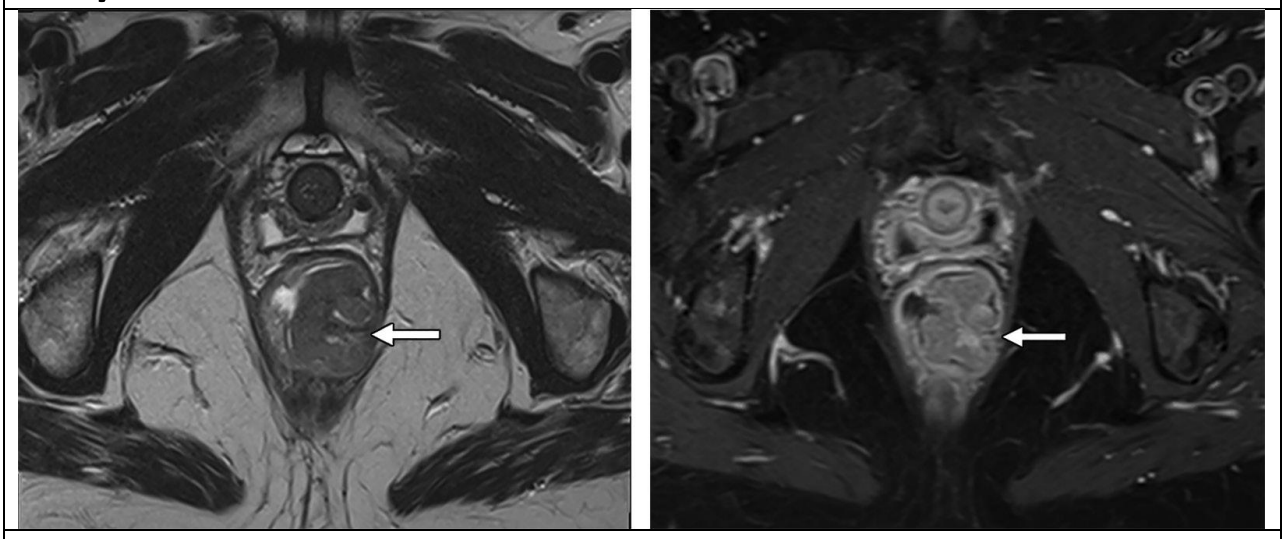
Table 3: TNM Classification of Anal Canal Cancer

Descriptor	Definition
Primary tumor (T)	
Tx	Primary tumor cannot be assessed
Tis	Carcinoma in situ
T1	Tumor less than 2 cm in greatest dimension
T2	Tumor between 2 and 5 cm in greatest dimension
T3	Tumor more than 5 cm in greatest dimension
T4	Tumor invading adjacent organs
Regional lymph nodes (N)	
Nx	Regional nodes cannot be assessed
N0	No regional lymph node metastasis
N1	Metastasis in the perirectal nodes
N2	Metastasis in unilateral internal iliac and/or inguinal nodes
N3	Metastasis in bilateral internal iliac or inguinal nodes
Distant metastasis (M)	
M0	No distant metastasis
M1	Distant metastasis

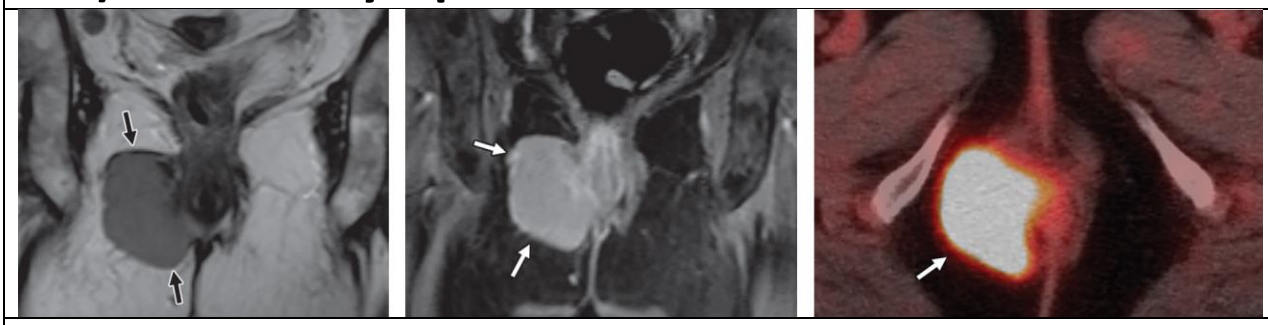


a. b. c.

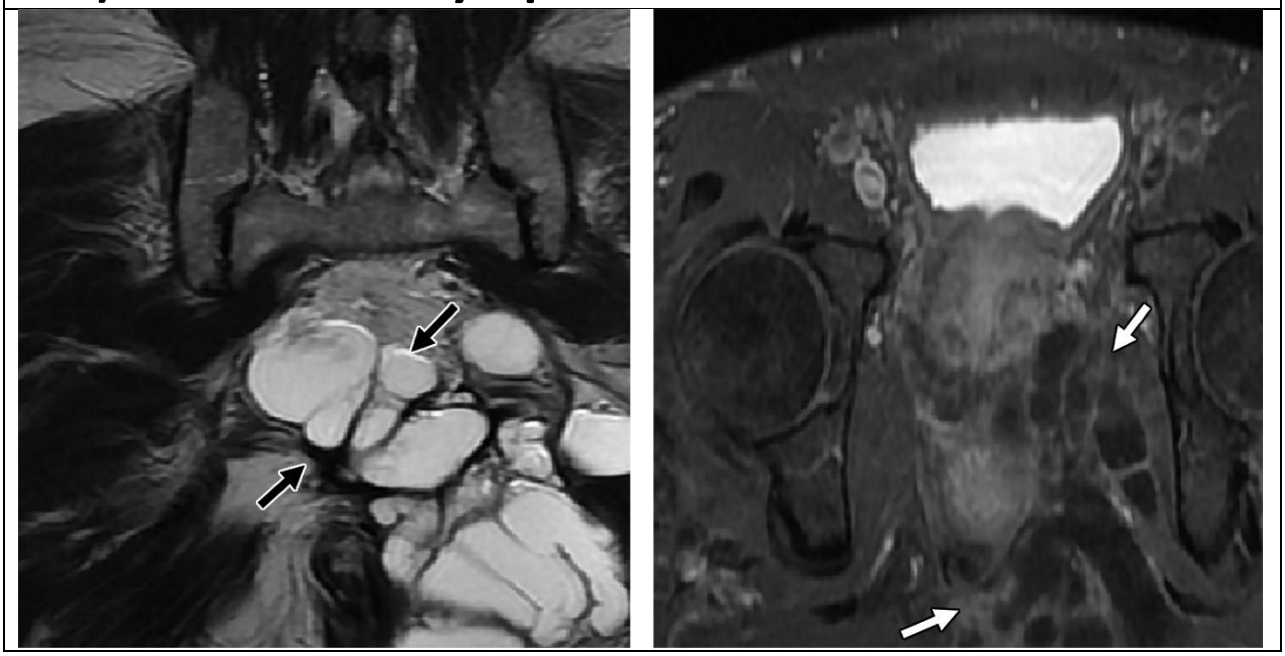
2) Anal Melanoma



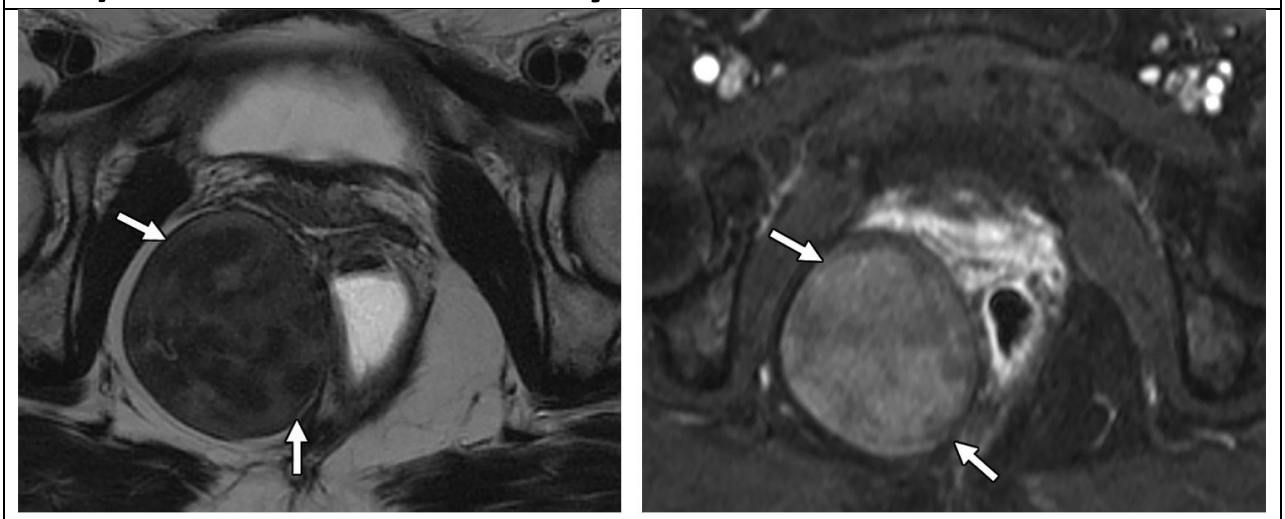
3) Anal Lymphoma



4) Perianal Lymphatic Malformation

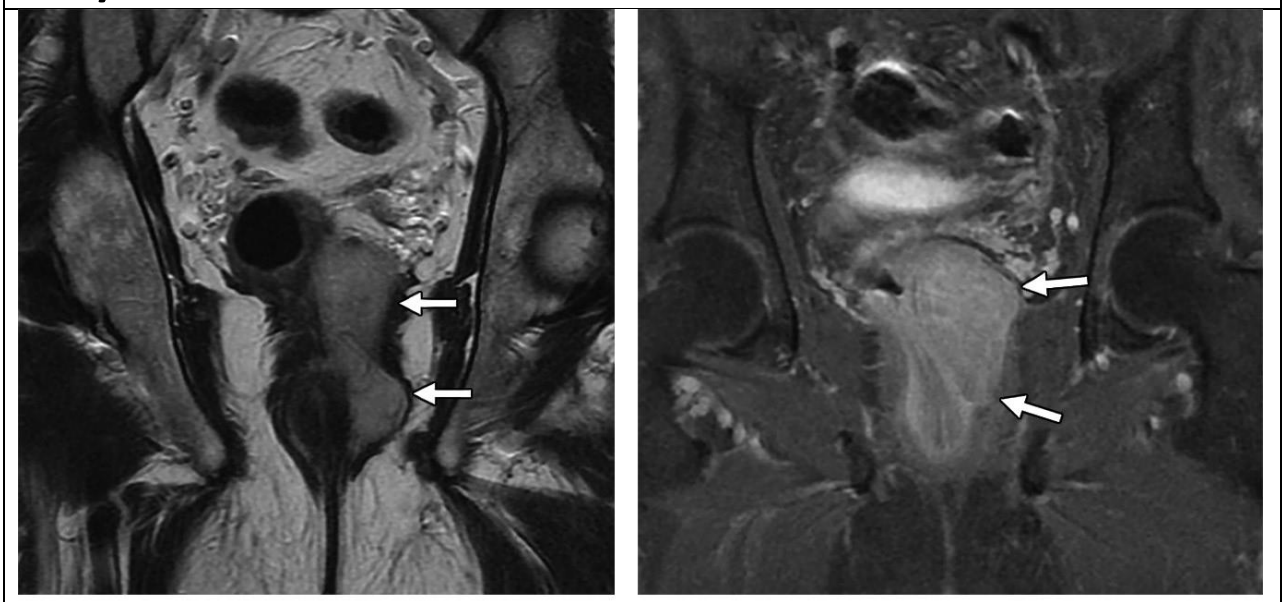


5) Perianal Leiomyoma



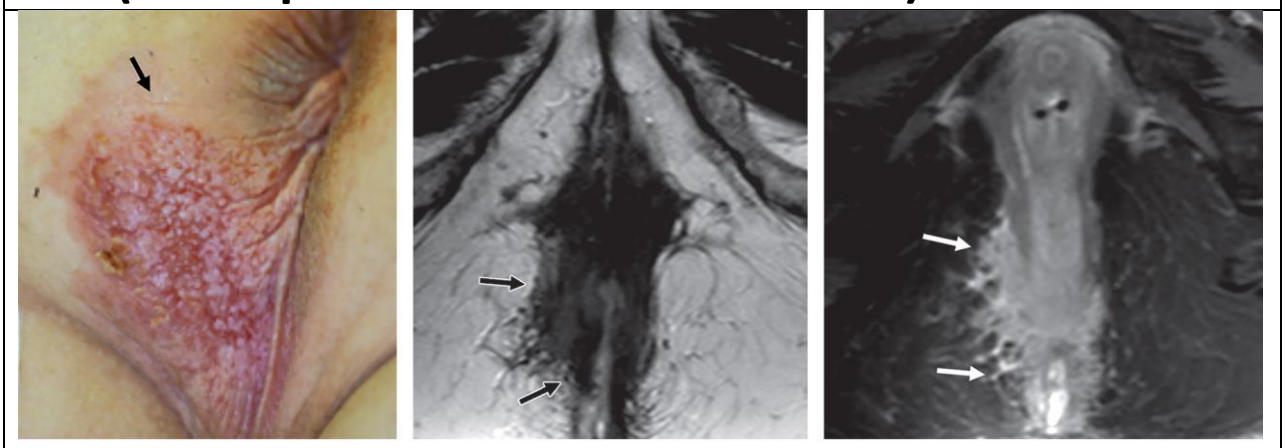
a. b.

6) Perianal GIST



a. b.

7) Paget Disease (Intraepithelial Adenocarcinoma)

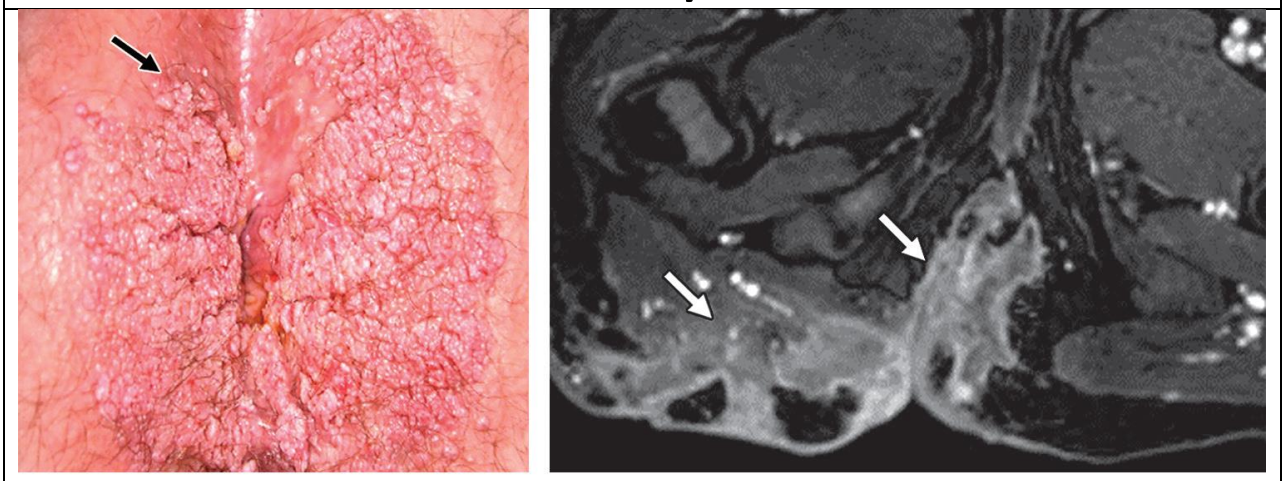


a. b. c.

8) Bowen Disease (Intraepithelial SCC)

- Perianal Bowen disease is considered a rare slow-growing premalignant lesion and is estimated to progress to invasive SCC

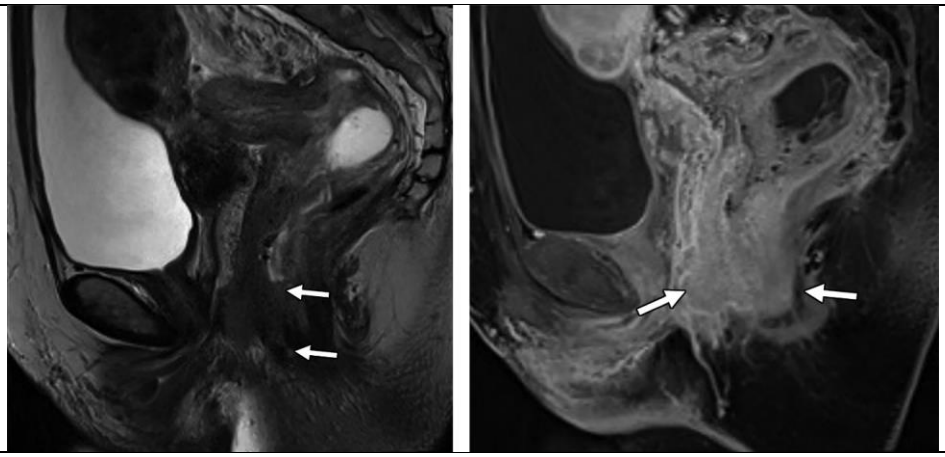
9) Verrucous Carcinoma (Giant condyloma acuminatum or Buschke-Löwenstein tumor)



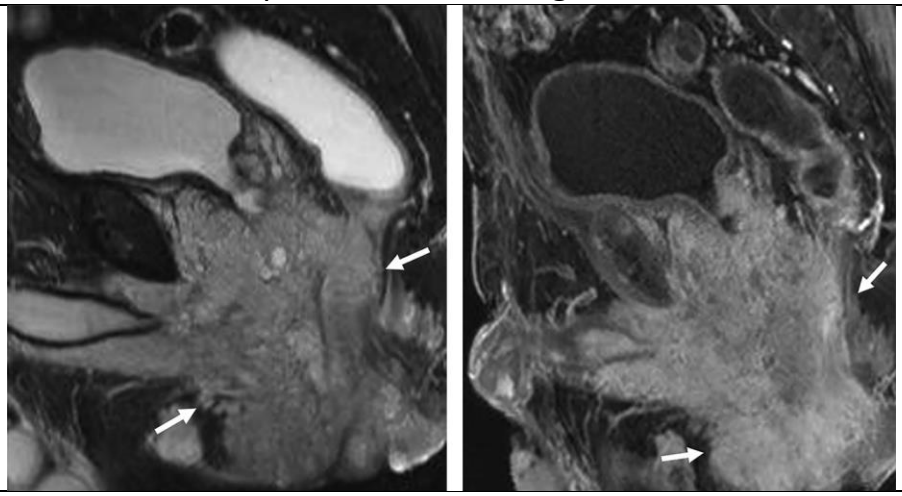
a. b.

10) Secondary Tumors

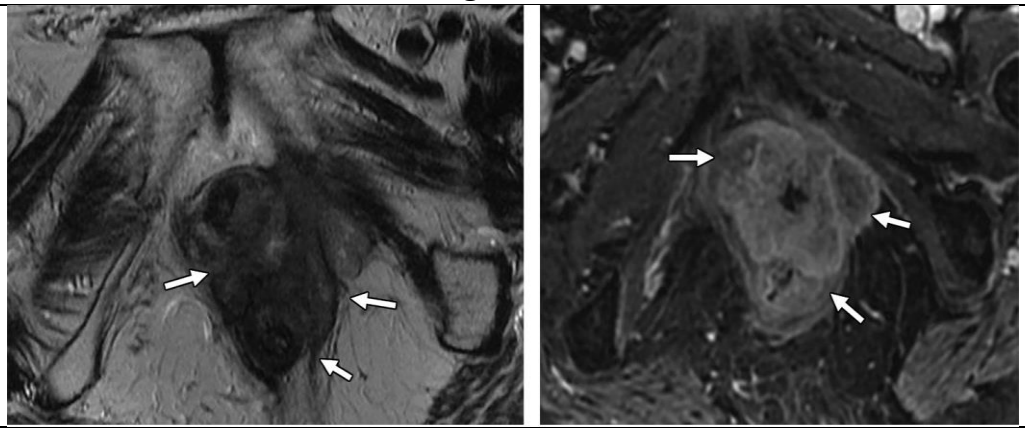
Rectal adenocarcinoma involving the lowest one-third of the rectum with direct extension and involvement of the anal canal



Adenoid cystic carcinoma of prostate with contiguous involvement of anal canal.



Stage IV cervical carcinoma with contiguous involvement of the anal canal.



GIT

Appendix

Anatomy

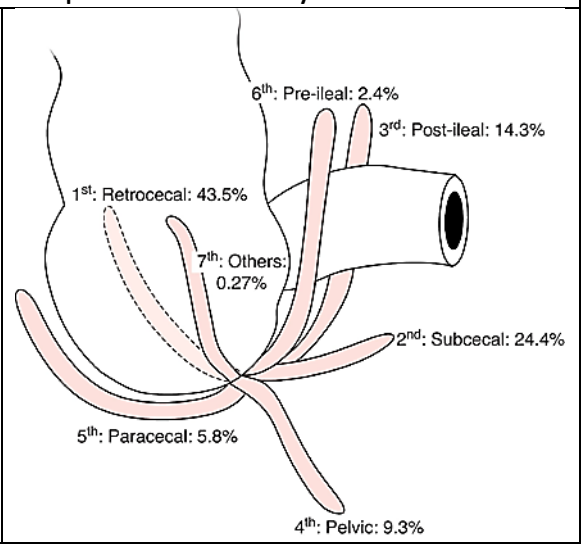
- The appendix or vermiform appendix is a blind muscular tube that arises from the caecum.
- 2-3 cm inferiorly to the ileocaecal valve
- Variable in length from 2-20 cm.
- The appendix lies on its own mesentery, the mesoappendix

Blood supply

- Arterial: appendicular artery, a branch of the ileocolic artery (itself from the superior mesenteric artery)
- Venous: similarly named veins draining to the portal venous system

Appendix position:

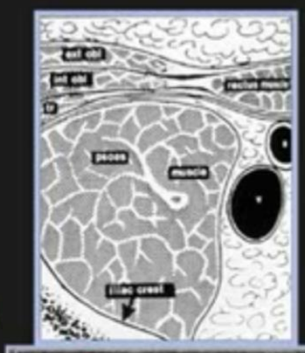
- **Retrocecal (43.5%)**
- **Subcecal (24.5%)**
- **Pre- or post-ileal (15%)**
- **Pelvic (10%)**

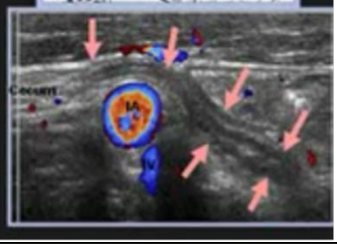


US Evaluation of the Appendix

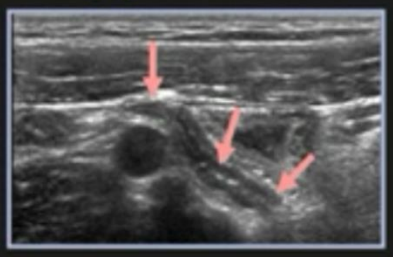
✓ *Graded compression of maximal point of pain and tenderness*

- examine pelvis for fluid (C5-2, C9-4)
- graded compression (L12-5 [C9-4, C5-2])
- identify psoas m and iliac vessels
- identify ascending colon
- appendix originates from cecum
- tip of appendix variable





Sonographic Features Normal Appendix

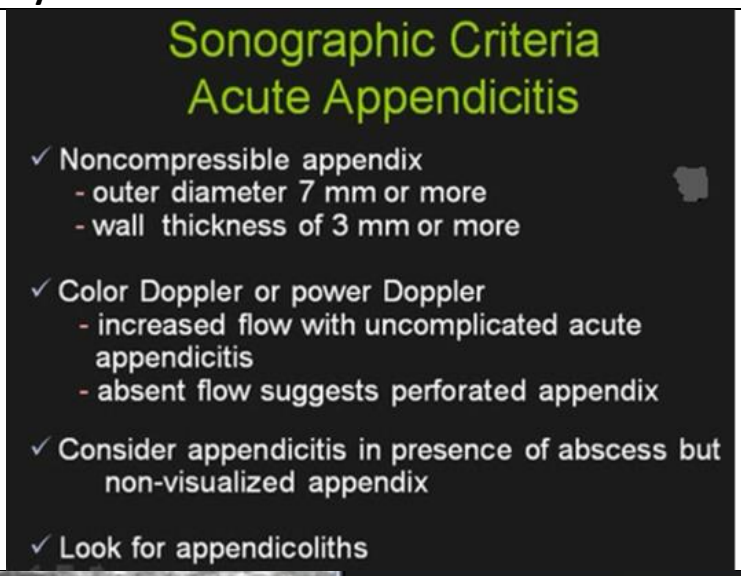


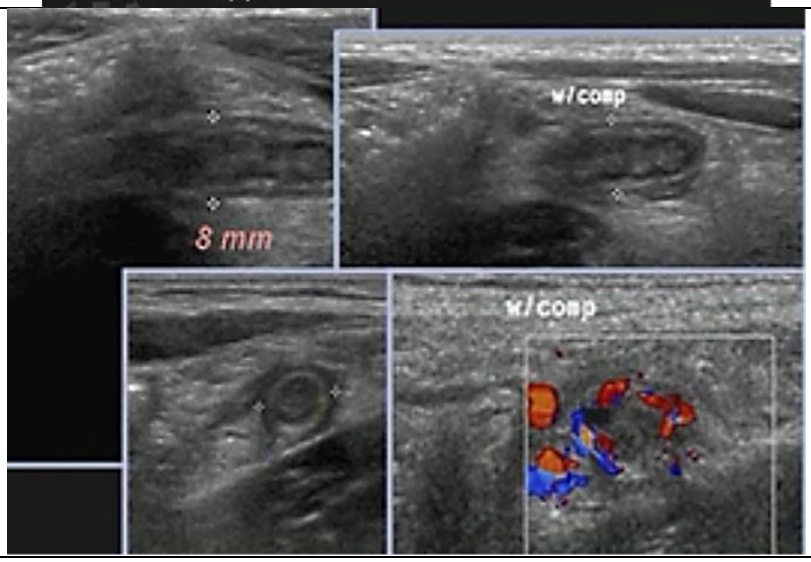
- ✓ Tubular structure terminating in a blind pouch
- ✓ Origin of appendix from base of cecum
- ✓ Inner echogenic rim and outer hypoechoic rim
- ✓ No peristalsis observable in tubular structure
- ✓ Maximum outer diameter appendix ≤ 6 mm
- ✓ Maximum thickness appendiceal wall ≤ 2 mm

Acute Appendicitis

- Acute appendicitis is the most common cause of emergency abdominal surgery.
- Appendicitis affects all age groups; it peaks in the early twenties and then gradually declines.
- M > F

- ***CT*** is warranted in a negative US study and is considered the modality of choice:
  - **Sensitivity 90%–95%**
  - **Specificity 95%–100%**


Sonographic Criteria
Acute Appendicitis
✓ Noncompressible appendix
- outer diameter 7 mm or more
- wall thickness of 3 mm or more
✓ Color Doppler or power Doppler
- increased flow with uncomplicated acute appendicitis
- absent flow suggests perforated appendix
✓ Consider appendicitis in presence of abscess but non-visualized appendix
✓ Look for appendicoliths



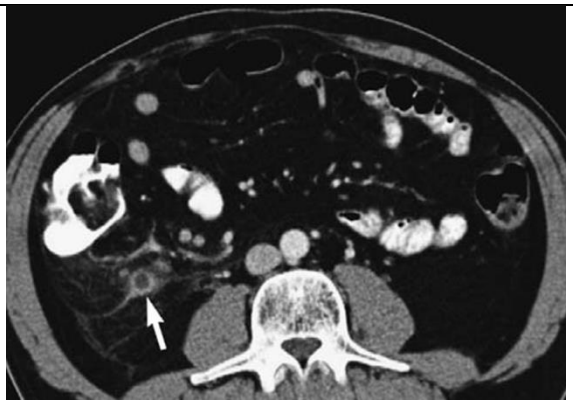
❖ CT /MRI Findings

- Enlargement of the appendix > 7 mm outer diameter (Normal diameter ≤ 6mm)
- Dilated Fluid-filled tubular structure lumen (Normally filled with air or contrast).
- Enhancement of the thickened appendiceal wall
- Appendicolith is a highly specific sign of appendicitis.
- Peri-appendiceal inflammation: Fat stranding.
- Arrowhead sign: Focal thickening of the cecum due to the inflammatory process.

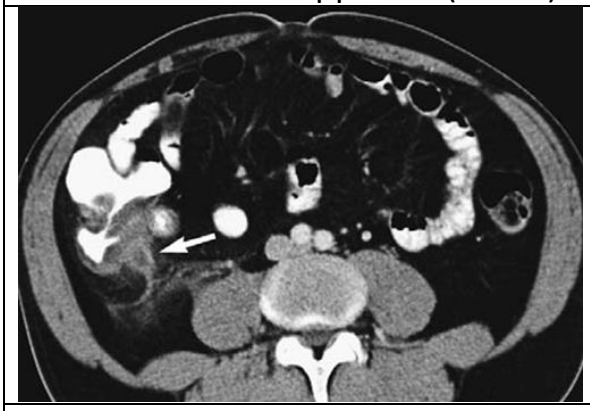
❖ Signs of Perforation:

- Extraluminal air
- Extraluminal appendicolith
- A defect in the enhancing appendiceal wall
- A phlegmon: diffuse inflammation of the periappendiceal fat with no or small, ill-defined fluid collections.
- An abscess: well-delineated fluid collection with rim enhancement

Enlarged appendix (arrow) + fluid filled
Appendicolith (arrowhead)
Thickened enhancing wall
Surrounding periappendiceal inflammation



Arrowhead sign: Thickening of the cecum At the base of the appendix (arrow).



Perforated appendicitis with periappendiceal abscess formation

Appendiceal Neoplasms

Primary Neoplasms of the Vermiform Appendix
Adenoma or adenocarcinoma (epithelial)
Mucinous
Colonic-type (nonmucinous)
Carcinoid tumor
Classic (common)
Tubular (rare)
Goblet cell carcinoid tumor
Lymphoma
Other tumors (rare)
Ganglioneuroma
Pheochromocytoma
Mesenchymal tumors
Kaposi sarcoma

❖Clinical Picture

- 30%–50% of all appendiceal neoplasms will manifest clinically with:
    - ***Acute appendicitis.***
- Other clinical manifestations include an
    - Asymptomatic palpable mass
    - intussusception
    - gastrointestinal bleeding
    - Increasing abdominal girth from rupture of a malignant mucocele, resulting in pseudomyxoma peritonei.

1) Appendicular Mucocele

- Mucoceles of the appendix are rare.
- Mucocele is a chronic cystic dilatation of the appendiceal lumen caused by an accumulation of mucin.
- Middle-aged patients

4 Histological Types

a) Simple Retention cyst

- Degenerative changes of the epithelium with no epithelial atypia.

b) Focal or diffuse mucosal hyperplasia

- Resembles hyperplastic polyp of colon
- Does not perforate

c) Mucinous cystadenoma

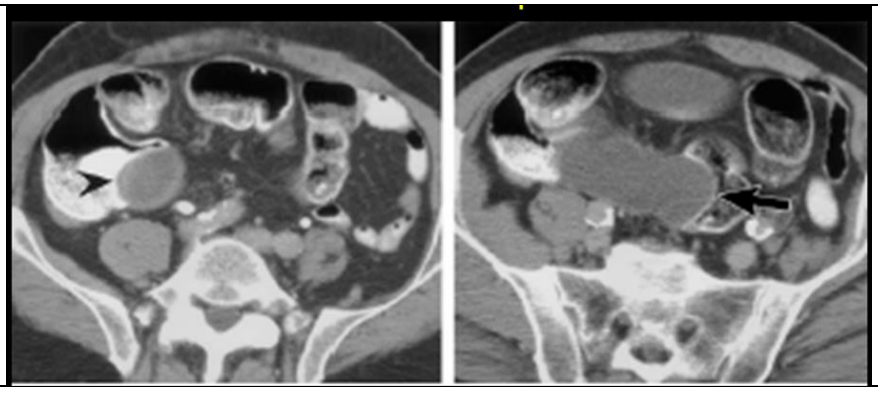
- A benign neoplasm
- Most common type of mucocele (about 50% of cases)
- 20% of cases perforate with mucus seeding

d) Mucinous cystadenocarcinoma

- One fifth as common as cystadenomas
- Risk of perforation, forming peritoneal implants

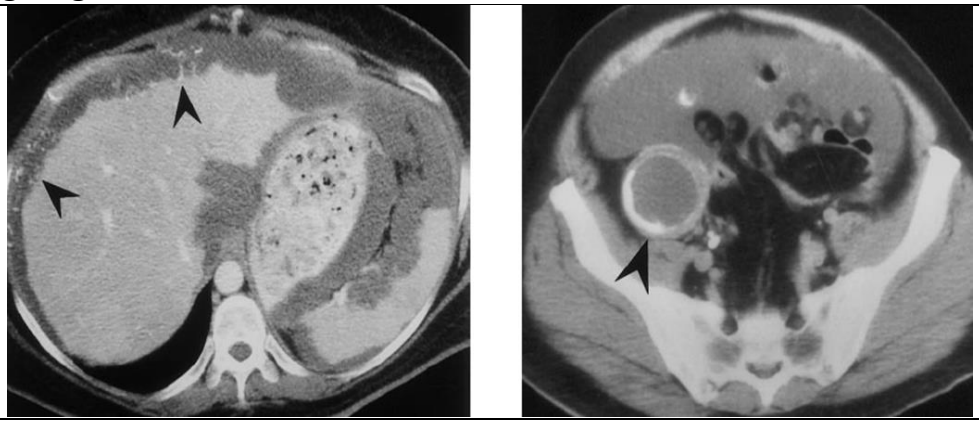
Imaging findings:

- Round or oval, thin wall sharply defined cyst; Near tip of cecum
- CT: homogeneous contents of low attenuation (HU of or near those of water)
- Calcifications of the appendiceal wall; this feature is suggestive of a mucocele.
- No surrounding inflammation.
- T2: tumor is hyperintense
- T1: Depending on the mucin concentration, the signal may be variably hypointense to isointense.
- +C: No enhancement



Pseudomyxoma Peritonei:

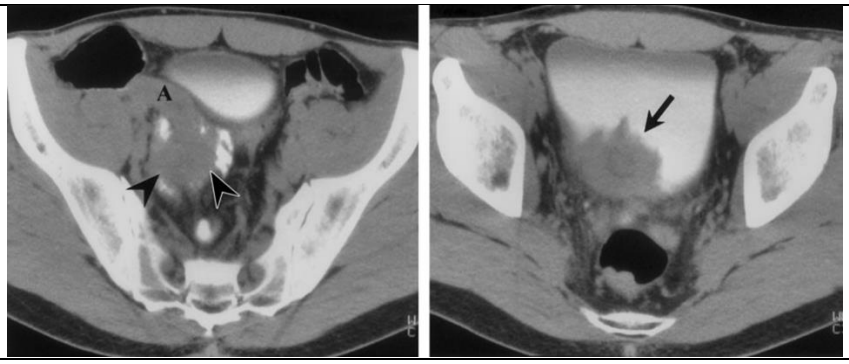
- Multi-loculated fluid collections
- Throughout the peritoneum, omentum and mesentery.
- Scalloping of visceral surfaces, particularly the liver
- Mass effect and distortion of bowel loops
- Scattered (curvilinear or punctate) calcifications may be frequently present
- CT: Low attenuation.
- T1: Low signal
- T2: High signal



2) Colonic Type (Non-mucinous) Adenoma and Adenocarcinoma

- Colorectal neoplasia rarely occur in the appendix.
- not to form mucocele.
- manifest clinically with appendicitis in old age related to malignant luminal obstruction

- Appendicular soft tissue mass + Bladder invasion + Hematuria



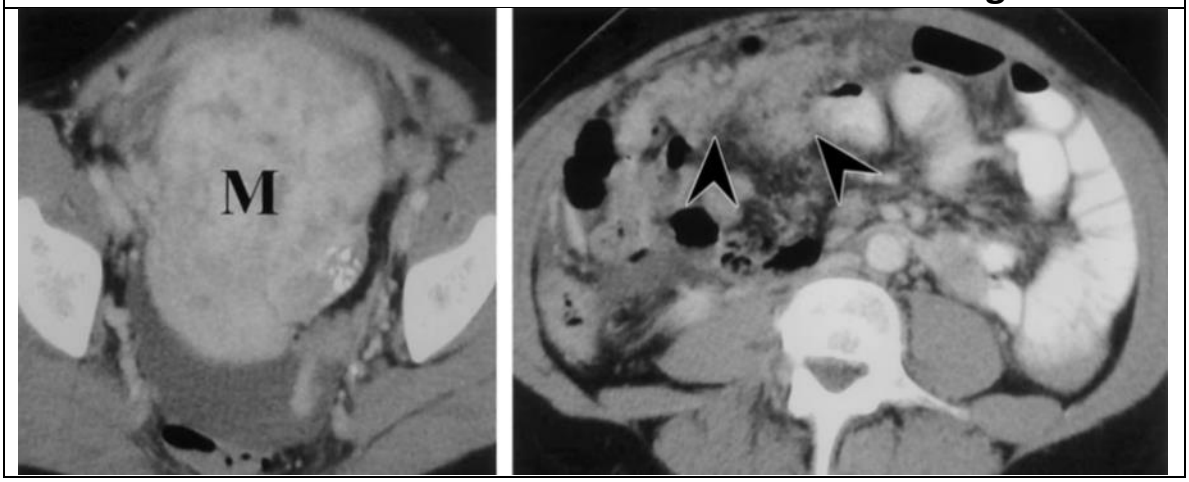
3) Appendiceal Carcinoid Tumors

- most common site for GIT carcinoid tumors
- most common type of appendiceal tumors
- Appendiceal tumors commonly present as acute appendicitis in young adults.
- Location: 70% are found in the distal third of the appendix (away from the base)
- Size: 95% are small < 2 cm in size
- 5-year survival rate > 90%

➢ Diffuse Infiltrative Pattern

Mesenteric soft tissue mass + Eccenteric calcification	Diffuse mural thickening of the appendix

➢ Metastatic Goblet Cell Carcinoid + Omental Caking



Peritoneum & Mesentery

Anatomy

The peritoneum

- is a serosal membrane that encases the peritoneal cavity, composes the mesenteries, partially or completely covers the abdominal and pelvic viscera.

Visceral peritoneum:

- Lines all the intraperitoneal organs, mesenteries, and omenta.

Parietal peritoneum:

- Lines the anterior, lateral and posterior abdominal walls, undersurface of the hemidiaphragm, anterior surface the retroperitoneum, and pelvis .

Mesentery:

- is a double fold of the peritoneum
- Suspends the small and large bowel
  - Small bowel mesentery
  - Transverse mesocolon
  - Sigmoid mesentery (or mesosigmoid)
  - Greater omentum: connects the stomach to the colon
  - Lesser omentum: connects the stomach to the liver
  - Mesoappendix: connects the apendix to the ileum

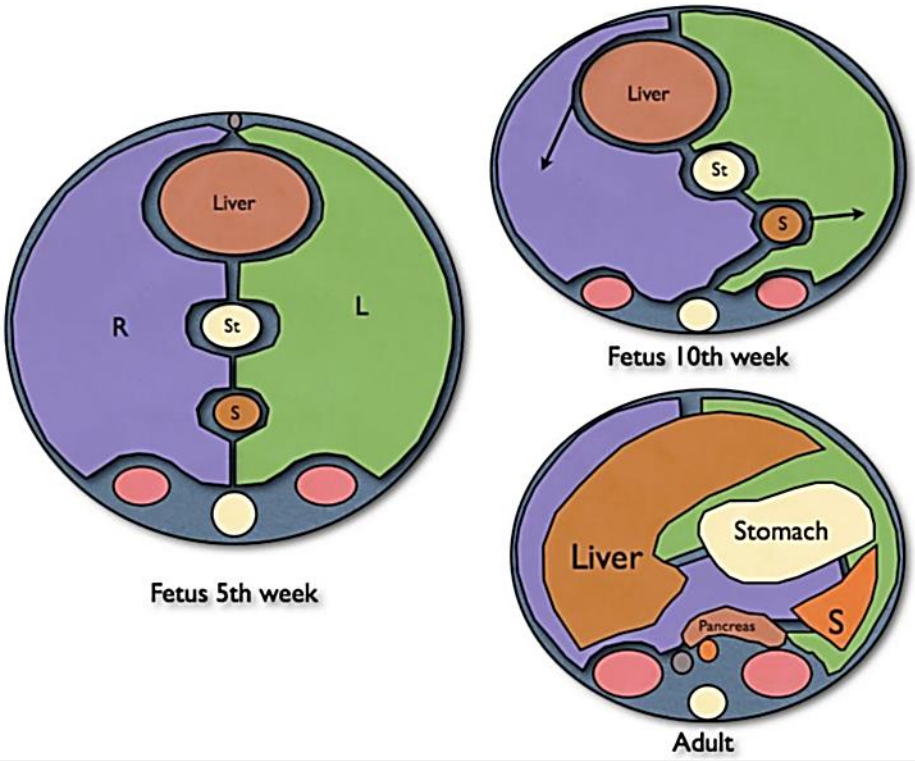
Peritoneal ligaments:

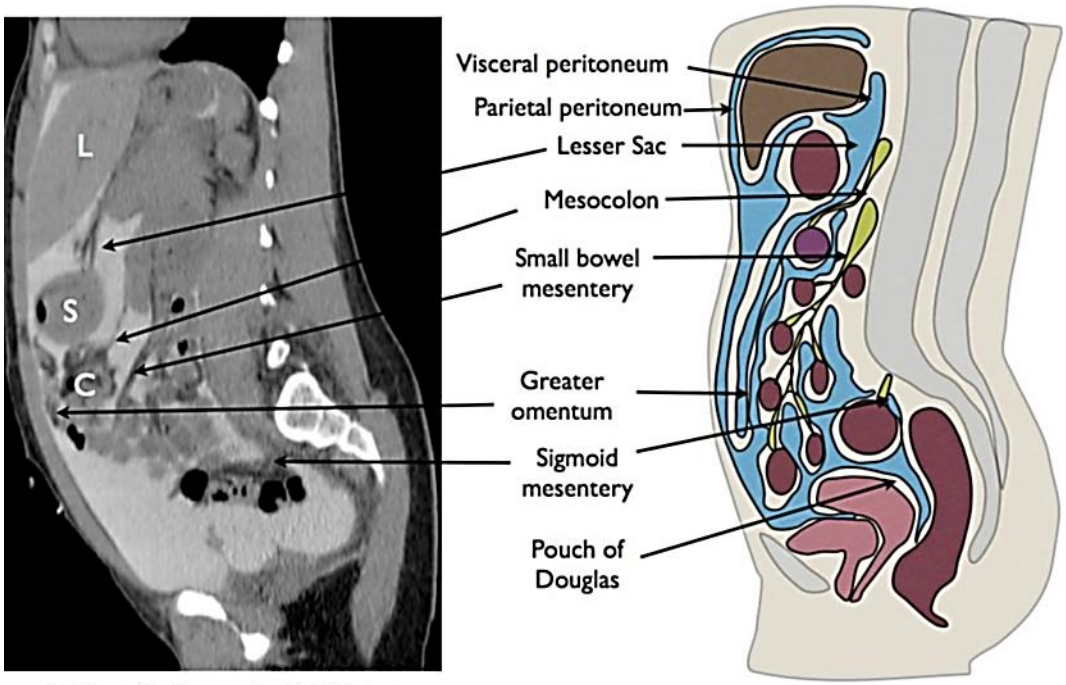
- are double layers or folds of peritoneum
- Suspend and support the intraperitoneal organs within the peritoneal cavity.
- Coronary, gastrohepatic, hepatoduodenal, falciform, gastrocolic, duodenocolic, gastrosplenic ,splenorenal, and phrenicocolic.

Omentum:

- is a mesentery or double layer of peritoneum peritoneum that extends from the stomach and duodenal bulb to adjacent organs.
  - The lesser omentum, which is made of two contiguous components called the gastrohepatic and hepatoduodenal ligaments, attaches the stomach and duodenal bulb to the liver.
  - The greater omentum is attached to the stomach and hangs like an apron from the transverse colon.

❖ *Peritoneal Embryological Development*



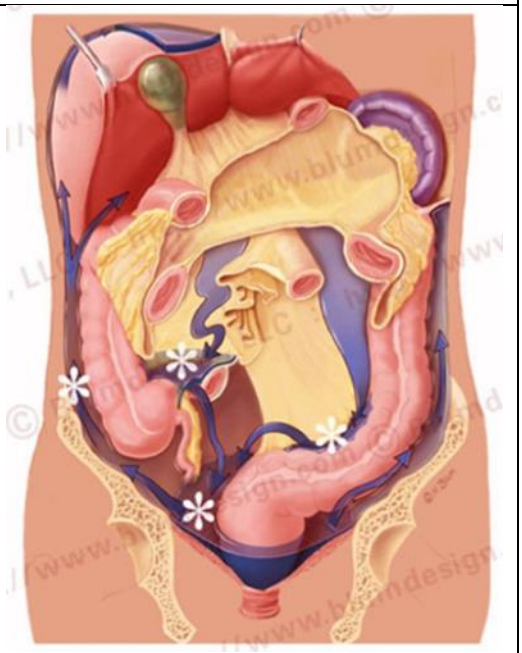


Peritoneal Cavity

- is potential space between parietal peritoneum, and visceral peritoneum.
    - in males: is continuous, resulting in a closed peritoneal cavity.
    - In females: is discontinuous at ostia of the oviducts, allowing communication between peritoneal cavity and extraperitoneal pelvis.

Peritoneal Circulation

- These compartments enable the peritoneal cavity to have a normal circulation for peritoneal fluid.
- In the normal abdomen without intraperitoneal disease, there is a small amount of peritoneal fluid that continuously circulates.
- The movement of fluid in this circulatory pathway is produced by the movement of the diaphram and peristalsis of bowel.
- It predominantly flows up the right paracolic gutter which is deeper and wider than the left and is partially cleared by the subphrenic lymphatics.
- The supramesocolic compartments communicates with the inframesocolic compartments by way of the right paracolic gutter.
- Free communication between the left paracolic gutter and left subphrenic space is prevented by the phrenicocolic ligament.



Peritoneal Spaces

- Greater and lesser peritoneal sacs
- The transverse mesocolon divides the greater peritoneum into the supra-mesocolic and infra-mesocolic spaces
- The supra-mesocolic space is divided into right and left by the falciform ligament
- The infra-mesocolic space is divided in right and left by the oblique small bowel mesentery.
- The bilateral paracolic and pelvic spaces are also peritoneal spaces

Supra-mesocolic Compartment

- The supramesocolic space is divided into right and left by falciform ligament
- The right supramesocolic spaces include the right subphrenic space, Morison pouch (subhepatic or hepatorenal space), and the lesser sac (omental bursa).
- The right subphrenic space communicates freely with the perihepatic and subhepatic spaces, including Morison's pouch, which communicates with the lesser sac via the epiploic foramen (foramen of Winslow).
- The connection between the left left subphrenic space and the paracolic gutter is partially limited by the phrenicocolic ligament.

Infra-mesocolic Spaces:

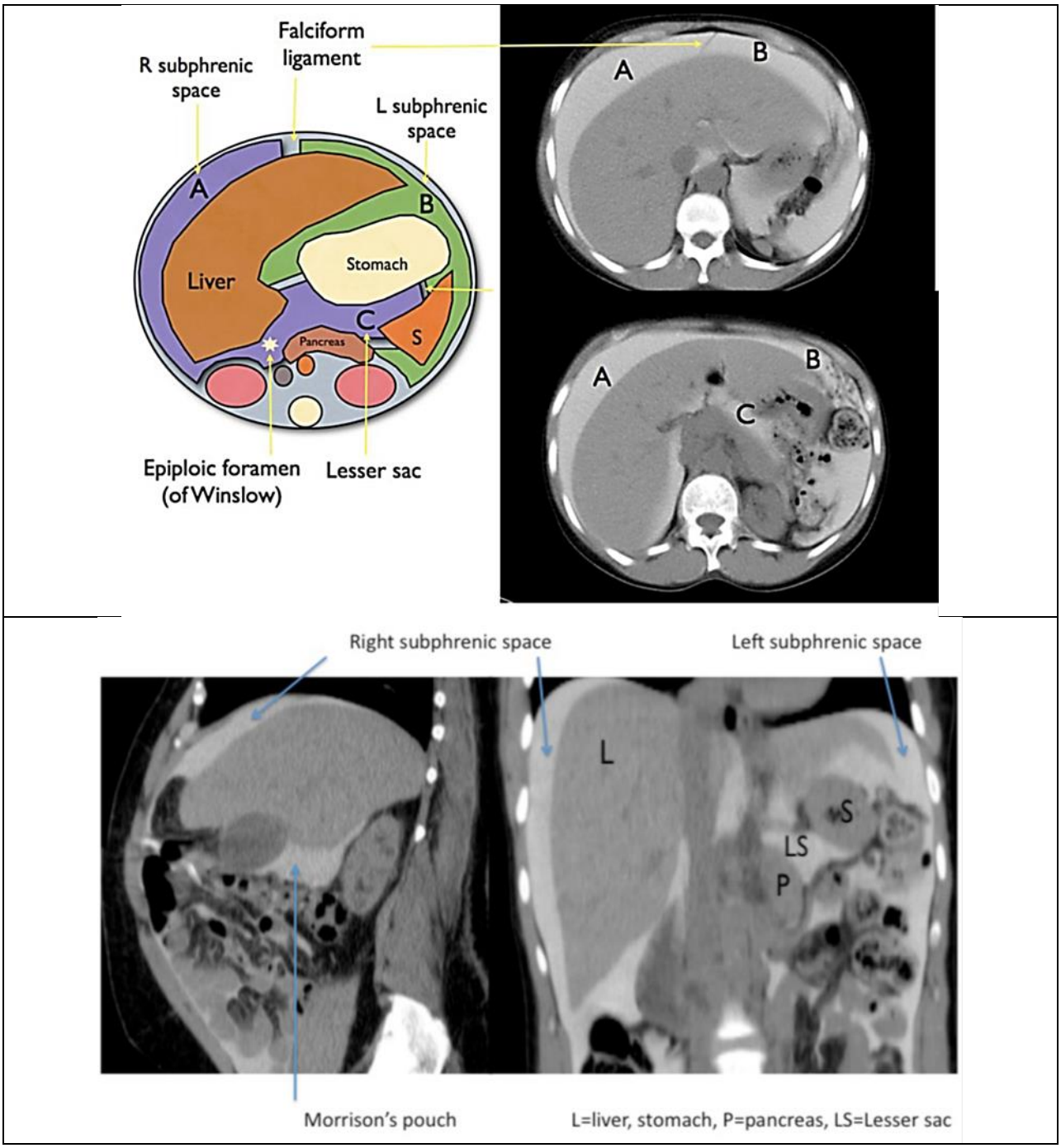
- The infra-mesocolic space is divided in right and left by the oblique small bowel mesentery.
- The infra-mesocolic spaces are separated from the supramesocolic spaces by the transverse mesocolon
- The infra-mesocolic spaces are separated from the paracolic gutters laterally by the ascending or descending colon.
- The smaller right inframesocolic space is limited inferiorly by attachment of small bowel mesentery to the cecum; collections in this space generally do not extend into the pelvis.
- The larger left inframesocolic space communicates freely with the pelvis

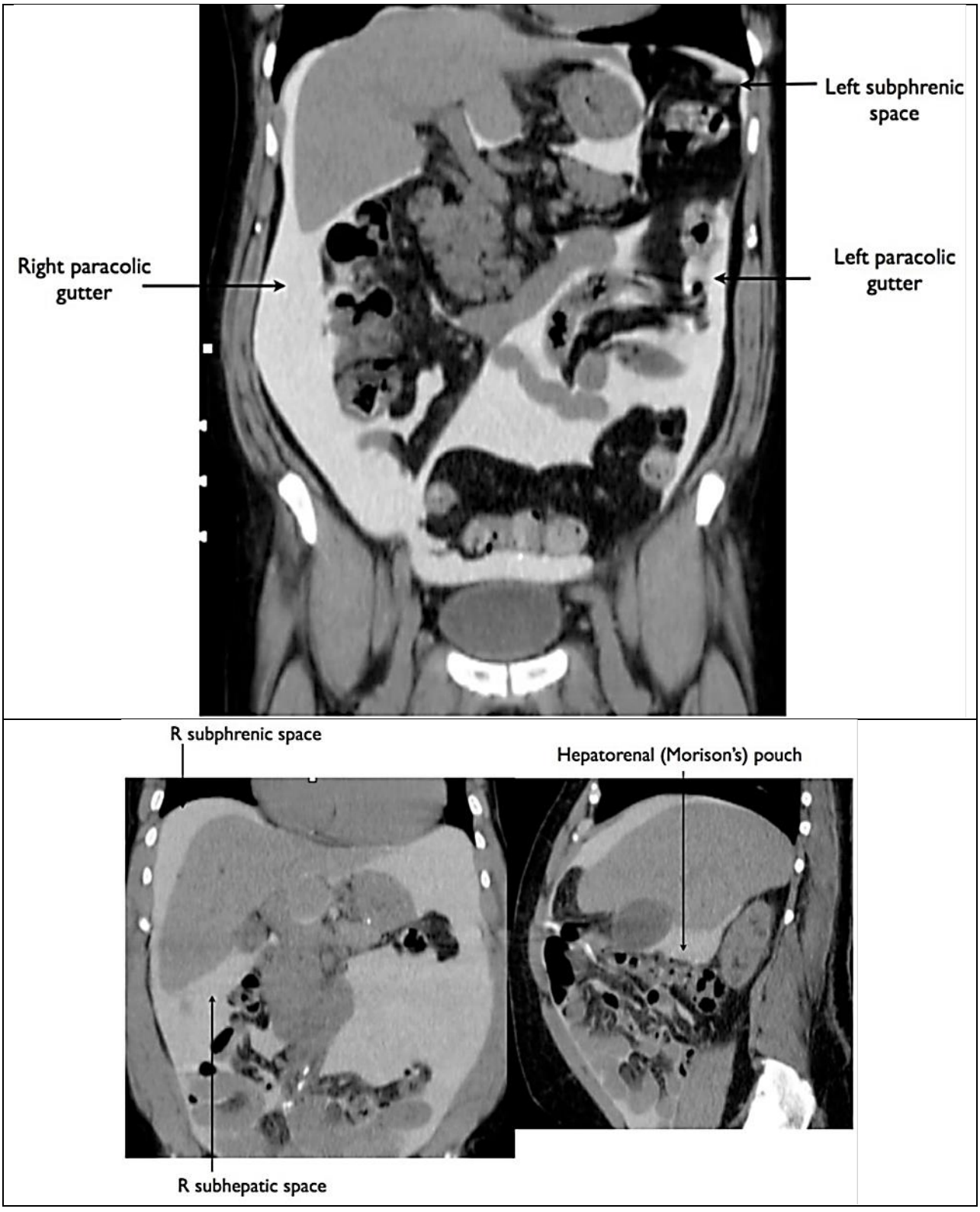
Paracolic Spaces:

- The paracolic spaces (gutters) are located lateral to the peritoneal reflections of the left and right sides of the colon.
- The right paracolic gutter is larger than the left and communicates freely with the right subphrenic space.
- The connection between the left paracolic gutter and the left subphrenic space is partially limited by the phrenicocolic ligament.
- Both the right and left paracolic gutters communicate with the pelvic spaces.

Pelvic Spaces

- In men, the most gravity-dependent site for fluid accumulation is the rectovesical space.
- In women, it is the retrouterine space (the pouch of Douglas)


Falciform ligament
R subphrenic space
L subphrenic space
A
B
Liver
Stomach
C
S
Pancreas
Epiploic foramen (of Winslow)
Lesser sac
A
B
C
Right subphrenic space
Left subphrenic space
L
S
LS
P
Morrison's pouch
L=liver, stomach, P=pancreas, LS=Lesser sac


Left subphrenic space
Right paracolic gutter
Left paracolic gutter
R subphrenic space
Hepatorenal (Morison's) pouch
R subhepatic space

Pouch of Douglas
Broad ligament

Peritoneal Lesions

1ry Tumors:
- Peritoneal mesothelioma
- Peritoneal serous carcinoma
- Leiomyomatosis Peritonealis Disseminata
- Desmoplastic Small Round Cell Tumor (DSRCT)

Metastatic
- Carcinomatosis
- Pseudomyxoma peritonei
- Lymphomatosis
- Sarcomatosis

Infectious / Inflammatory
- Granulomatous (TB) peritonitis
- Inflammatory pseudotumor
- Sclerosing peritonitis

Miscellaneous
- Endometriosis
- Gliomatosis peritonei
- Osseous metaplasia
- Cartilagenous metaplasia
- Melanosis
- Splenosis

Cystic
- Mesenteric cyst
- Cystic Mesothelioma
- Pancreatic pseudocyst / Non Pancreatic Pseudocyst
- Paraovarian cyst / Peritoneal inclusion cyst
- Seroma / Abscess / Hematoma
- Fetus in feto
- Teratoma

I- Primary Peritoneal Tumors

Classification of Primary Tumors of the Peritoneum

Mesothelial tumors
- Peritoneal malignant mesothelioma
- Well-differentiated papillary mesothelioma
- Multicystic mesothelioma
- Adenomatoid tumor

Epithelial tumors
- Primary peritoneal serous carcinoma
- Primary peritoneal serous borderline tumor

Smooth muscle tumor
- Leiomyomatosis peritonealis disseminata

Tumors of uncertain origin
- Desmoplastic small round cell tumor
- Solitary fibrous tumor

A- Peritoneal Mesothelioma

Characteristic	Subtype of Peritoneal Mesothelioma		
	Malignant Peritoneal Mesothelioma	Cystic Mesothelioma	Well-Differentiated Papillary Mesothelioma
Predilection	Older men during fifth and sixth decades	Young to middle-aged women	Reproductive-age women
Predisposing factor	Asbestos exposure	Previous abdominal surgery or pelvic inflammatory disease	NA
Clinical course	Poor prognosis despite multitechnique therapy	Hormone-sensitive response	Indolent course, rare malignant change
CT findings	Dry appearance: peritoneum-based masses Wet appearance: ascites, irregular or nodular peritoneal thickening, and omental masses Scalloping or direct invasion of adjacent abdominal organs	Multilocular cystic mass, multiple unilocular thin-walled cysts, or unilocular cystic mass	Peritoneal thickening, multiple peritoneal nodules, omental infiltration, and ascites
Differential diagnosis (differential points)	• Peritoneal carcinomatosis (higher incidence of liver metastasis and lymphadenopathy, prominent ascites, less severe peritoneal thickening) • Serous papillary carcinoma of peritoneum (elderly women and postmenopausal women) • Tuberculous peritonitis (smooth peritoneal thickening, mesenteric lymphadenopathy with central necrosis, high-attenuation ascites, and combined with splenomegaly) • Peritoneal lymphomatosis (retroperitoneal or mesenteric lymphadenopathy and lack of omental involvement)	• Cystic lymphangioma (affects younger patients, same distribution between sexes, no regional predilection) • Endometriosis (thick wall, thick internal septa, high-attenuation debris) • Cystic epithelial neoplasms of the ovaries • Pseudomyxoma peritonei	• Peritoneal carcinomatosis • Serous papillary carcinoma of peritoneum • Tuberculous peritonitis

1) Peritoneal Malignant Mesothelioma

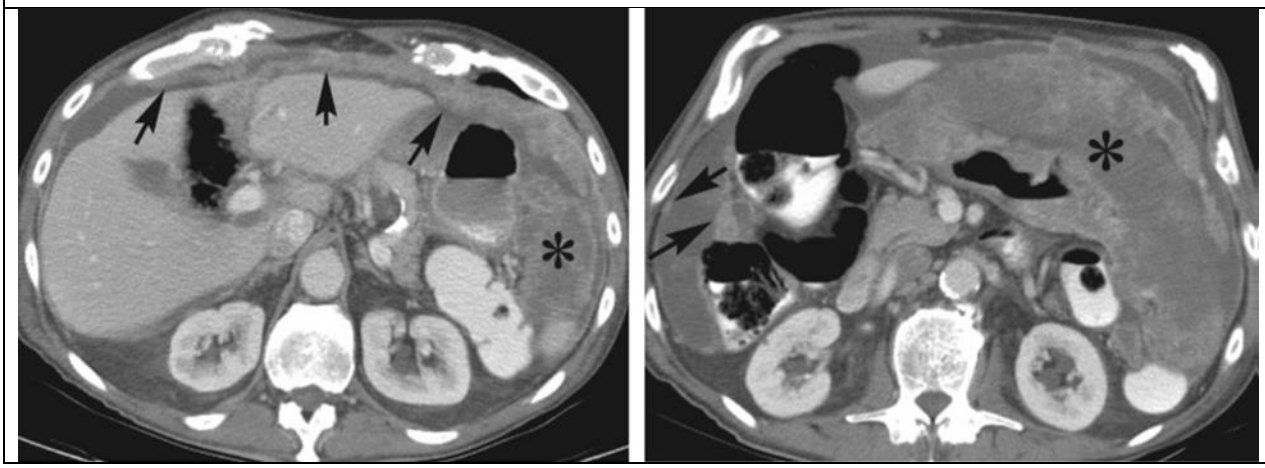
- Uncommon malignant neoplasm that arises from mesothelial cells or multipotential subserosal mesenchymal cells of the pleura, peritoneum, pericardium, or tunica vaginalis of the testis.
- Pleura : more common
- Peritoneal primary mesotheliomas account for 6%–10% of malignant mesotheliomas
- M>>>>> F
- Median age at presentation of 60 year

Risk Factors:

- Asbestos exposure
- Therapeutic irradiation
- Exposure to simian virus 40
- Chronic pleural or peritoneal irritation

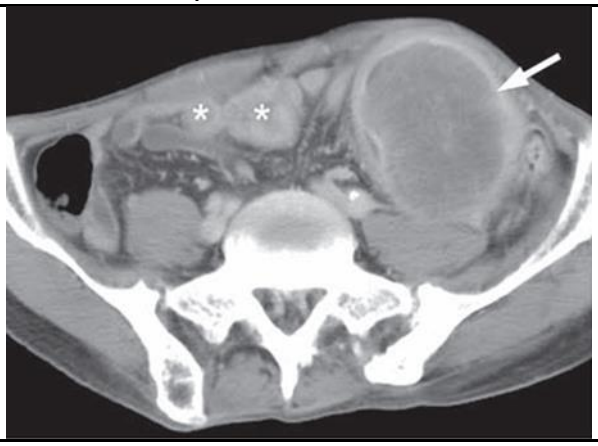
Diffuse Pattern:

- Diffuse peritoneal irregular nodular => sheet like fashion => encasing solid and hollow visceral organs.
- Ascites is variable ranging from massive, diffuse ascites to focal, small, loculated collections of fluid



Localized Pattern:

- Heterogeneous, solid intraperitoneal mass
- Invasion of adjacent visceral structures such as the liver, spleen, or pelvic organs may occur
- Localized, loculated ascitic fluid may be present.
- Scattered peritoneal nodule



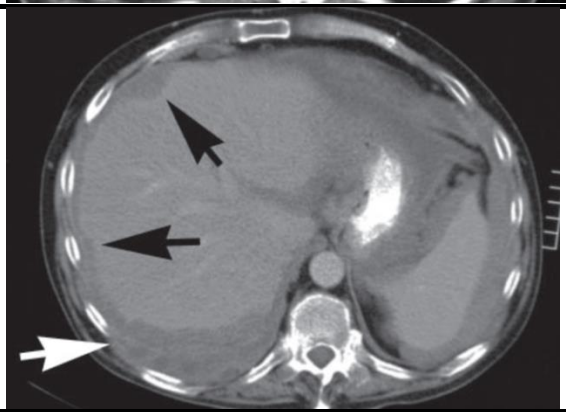
Omental Cake:

- Nodular soft tissue within the greater omentum (arrows)

Retrperitoneum & Diaphragm:

Diffuse peritoneal malignant mesothelioma may

- Invade the retroperitoneum, extend into the abdominal wall,
- Grow through the diaphragm into the pleural cavity.



Pleated or Stellate Appearance

- Tumor infiltration of the small bowel mesentery fixates the small bowel and its mesentery, straightening the course of the mesenteric vessels.
- The straight mesenteric vessels, as well as linearly oriented tumor in the mesentery, produce the pleated appearance.
- The term stellate mesentery refers to thick perivascular bundles, which produce prominent vessels that, when viewed in cross section adjacent to mesenteric fat, appear similar to stars in the sky.

Pleural Calcification

- The diagnosis of malignant peritoneal mesothelioma is strongly suggested if there is concomitant asbestos-related pleural and lung parenchymal disease such as pleural plaque

Nodal metastases:

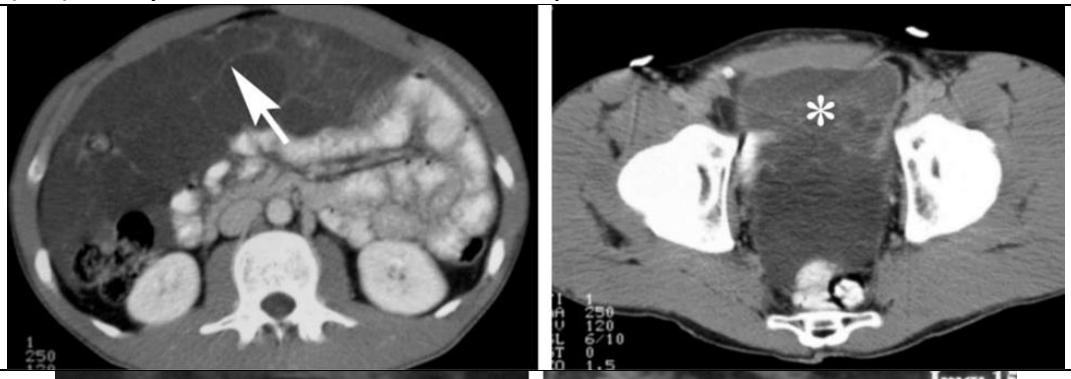
- ***Uncommon***
- The presence of lymph node enlargement in a patient with diffuse peritoneal disease suggests another etiology,
- such as diffuse peritoneal carcinomatosis, lymphomatosis, or tuberculous peritonitis

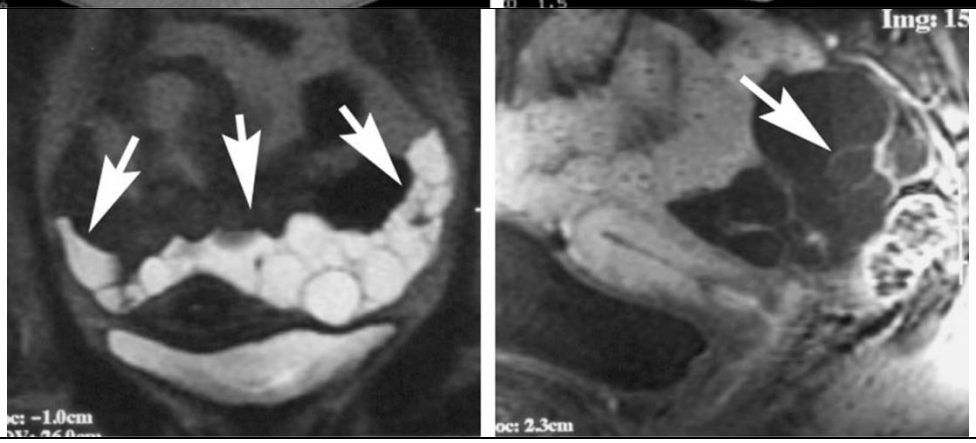
2) Multicystic Mesothelioma

- Unusual, multilocular cystic tumor that most commonly arises from the pelvic surfaces of the peritoneum.
- Predominantly in women (mean age, 37 years).
- Men (mean age, 47 years)

Imaging findings:

- Well defined multilocular cystic pelvic mass.
- CT: Low attenuating
- Calcification is generally not a feature
- T1 : fluid components show low signal
- T2 : fluid components show high signal
- C+ (Gd) : may show enhancement of septate





3) Well-differentiated Papillary Mesothelioma

- Rare.
- It occurs predominantly in women
- most often arises from the peritoneal surfaces of the pelvis.

B-Primary Peritoneal Serous Carcinoma

- is an epithelial tumor that arises from the peritoneum.
- Primary peritoneal serous carcinoma is thought to arise from extra-ovarian mesothelium that has müllerian potential.

The following criteria have been established to make the diagnosis of primary peritoneal serous carcinoma:

- ✓ Both ovaries are normal
- ✓ The involvement of extraovarian sites must be greater than the involvement on the surface of either ovary
- ✓ The ovarian involvement is limited to the ovarian surface epithelium, either without stromal invasion or involving the cortical stroma with tumor size less than 5 x 5 mm

Imaging findings:

(Primary peritoneal serous carcinoma mimicking peritoneal carcinomatosis)

- Ascites + peritoneal nodules and thickening + omental nodules and masses
- Normal ovaries

a. b.

C- Leiomyomatosis Peritonealis Disseminata

- Leiomyomatosis peritonealis disseminata (also called diffuse peritoneal leiomyomatosis) is a rare, benign entity characterized by innumerable smooth muscle nodules throughout the peritoneal cavity.

Imaging findings:

- Multiple well-circumscribed solid masses in the peritoneal cavity
- CT: heterogeneous attenuation
- T1: isointense relative to muscle
- T2: Low signal
- +C: heterogeneous enhancement similar to uterine leiomyomas.

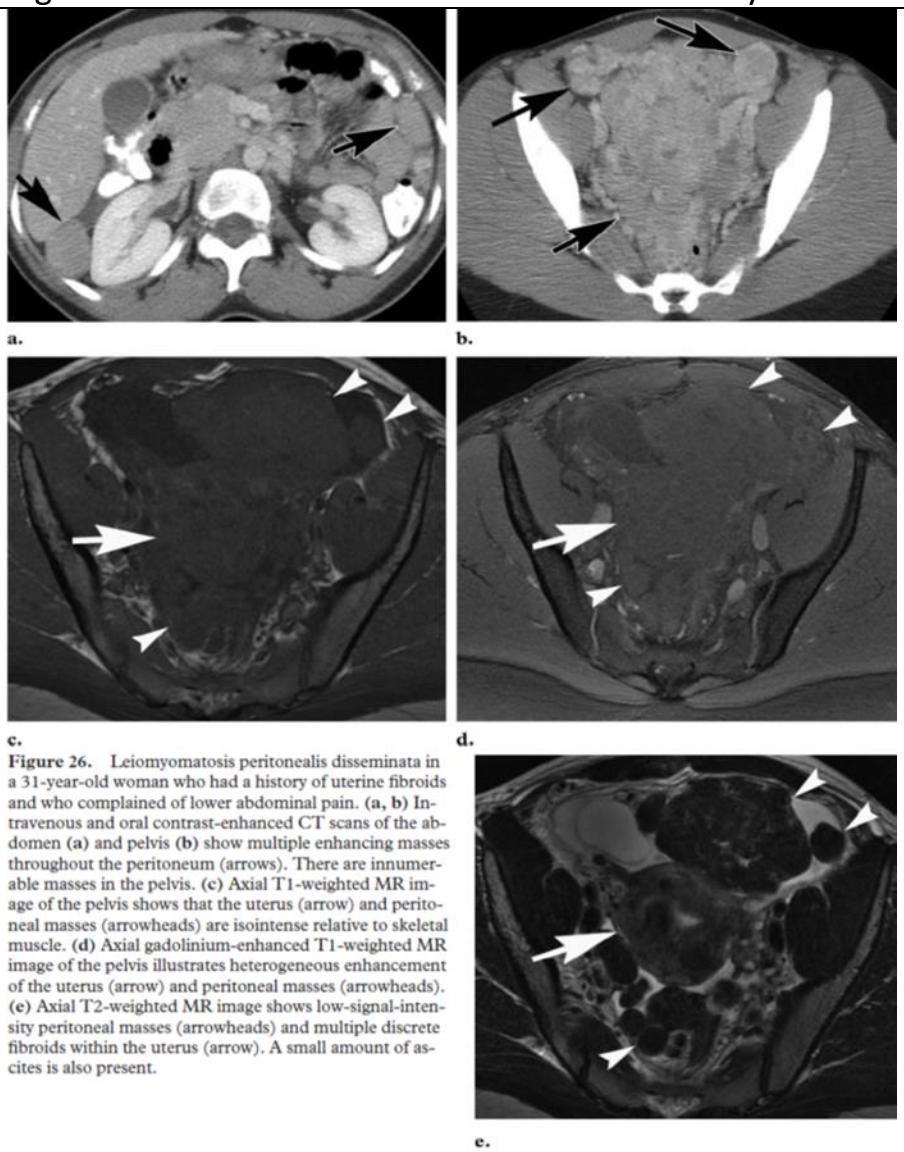


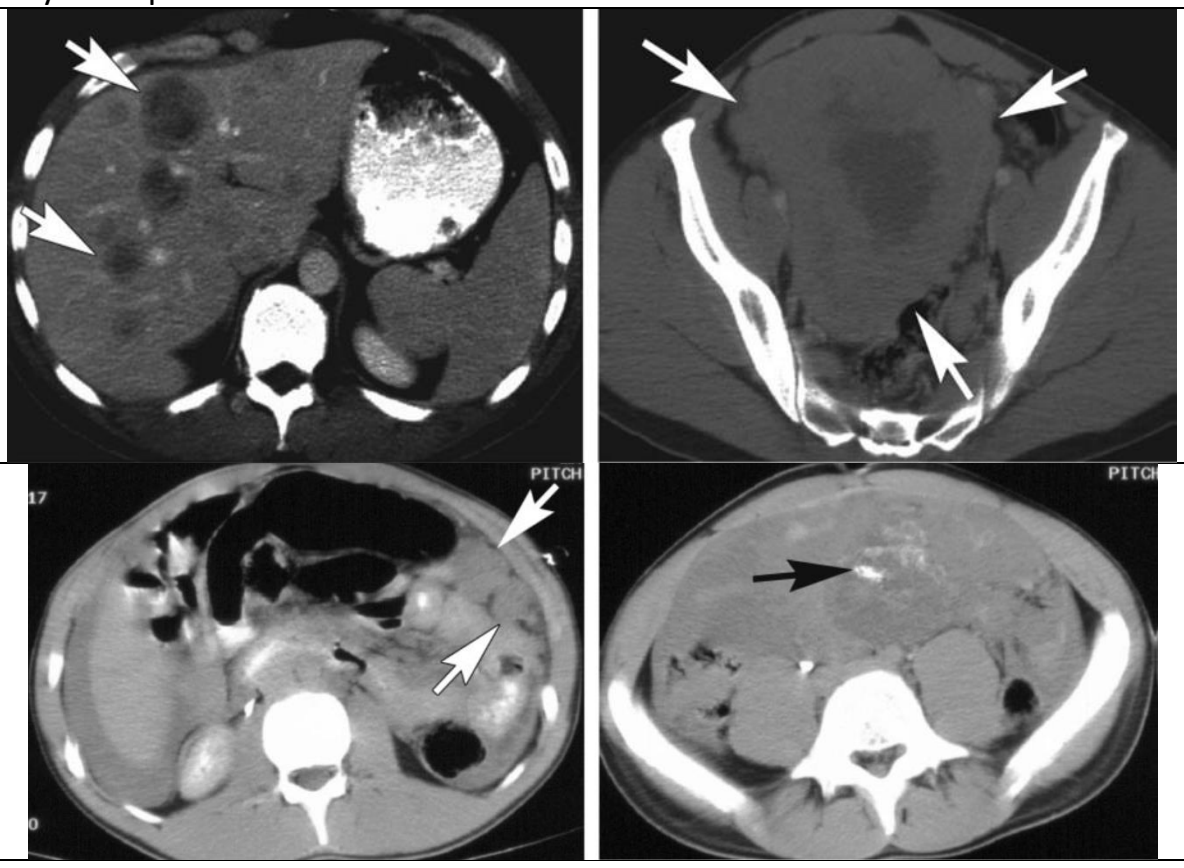
Figure 26. Leiomyomatosis peritonealis disseminata in a 31-year-old woman who had a history of uterine fibroids and who complained of lower abdominal pain. **(a, b)** Intravenous and oral contrast-enhanced CT scans of the abdomen **(a)** and pelvis **(b)** show multiple enhancing masses throughout the peritoneum (arrows). There are innumerable masses in the pelvis. **(c)** Axial T1-weighted MR image of the pelvis shows that the uterus (arrow) and peritoneal masses (arrowheads) are isointense relative to skeletal muscle. **(d)** Axial gadolinium-enhanced T1-weighted MR image of the pelvis illustrates heterogeneous enhancement of the uterus (arrow) and peritoneal masses (arrowheads). **(e)** Axial T2-weighted MR image shows low-signal-intensity peritoneal masses (arrowheads) and multiple discrete fibroids within the uterus (arrow). A small amount of ascites is also present.

D-Desmoplastic Small Round Cell Tumor (DSRCT)

- Rare malignancy
- Age: ***adolescent and young adult males***.
- It is a distinctive clinic-pathologic entity in the family of primitive pediatric tumors that are compose of small round blue cells; a group that includes Wilms tumor, Ewing sarcoma, peripheral primitive neuroectodermal tumor, and Askin tumor.

Imaging findings:

- Multiple intraabdominal soft-tissue masses that involve the omentum and serosal surfaces without an apparent organ of origin, particularly in the retrovesical or rectouterine spaces
- Punctate calcification or necrosis in the mass
- Ascites
- Hepatic metastases
- Lymphadenopathy
- Bowel obstruction
- Hydronephrosis



Desmoplastic small round cell tumor with bone metastasis

II- Peritoneal Metastatic

Mechanisms of Intraperitoneal dissemination of tumor cells

- Intraperitoneal seeding
- **Direct invasion:** occurs through contiguous extension of GIT or ovarian tumor
- **Hematogenous dissemination:** Extraabdominal primary malignancies (melanoma and breast and lung carcinomas spread hematogenously to the antimesenteric border of the intestine and peritoneum
- **Lymphatic dissemination:** lymphatic dissemination is an important factor in the longitudinal growth of carcinoma along the wall of the stomach or intestine.

Primary intraperitoneal seeding occurs most commonly from:

- Stomach, colon, appendix, gallbladder, Pancreas, ovary, breast, lung, uterus.

Important Sites of Occult Tumor:

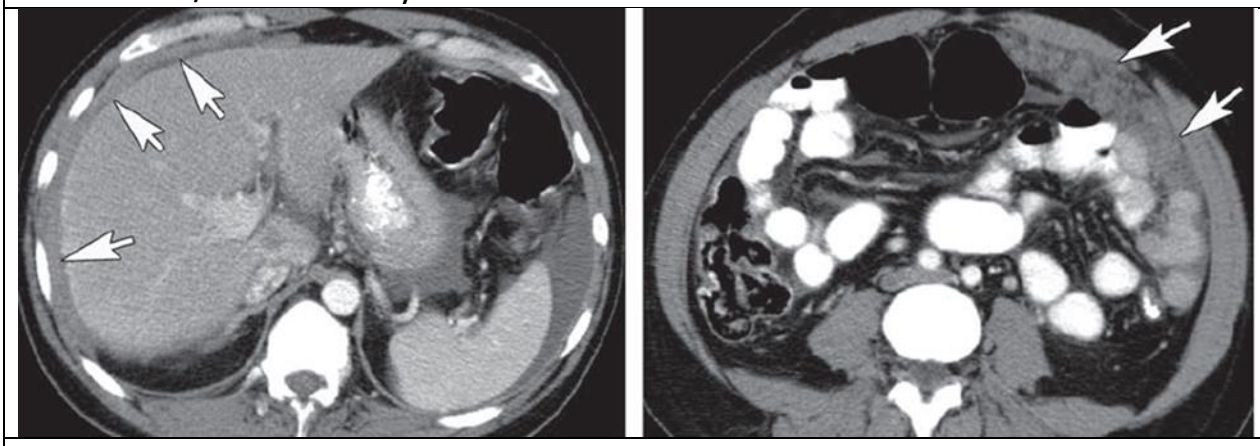
- Pouch of Douglas, Retrovesical space, Ileocecal region, Paracolic gutters, Subhepatic space, Right subdiaphragmatic space, Root of small bowel mesentery

A- Peritoneal Carcinomatosis

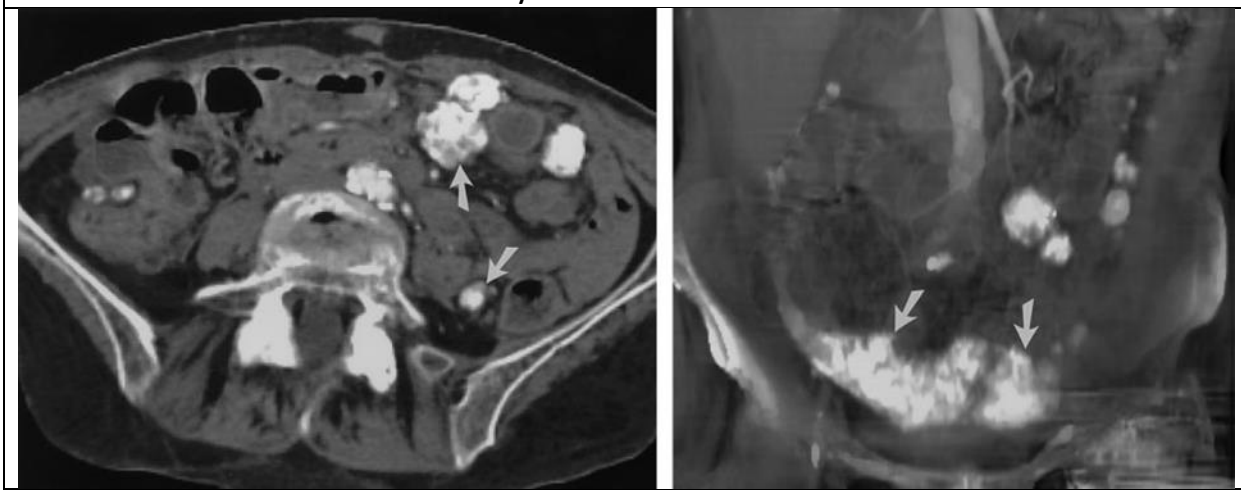
Imaging Findings:

- Ascites is a common finding in peritoneal carcinomatosis,
- Discovery of new-onset ascites should lead to a careful search for findings that would indicate a malignant etiology.
- Loculation of ascitic fluid is one of the most helpful features
- Thickening, nodularity, enhancement of the peritoneum

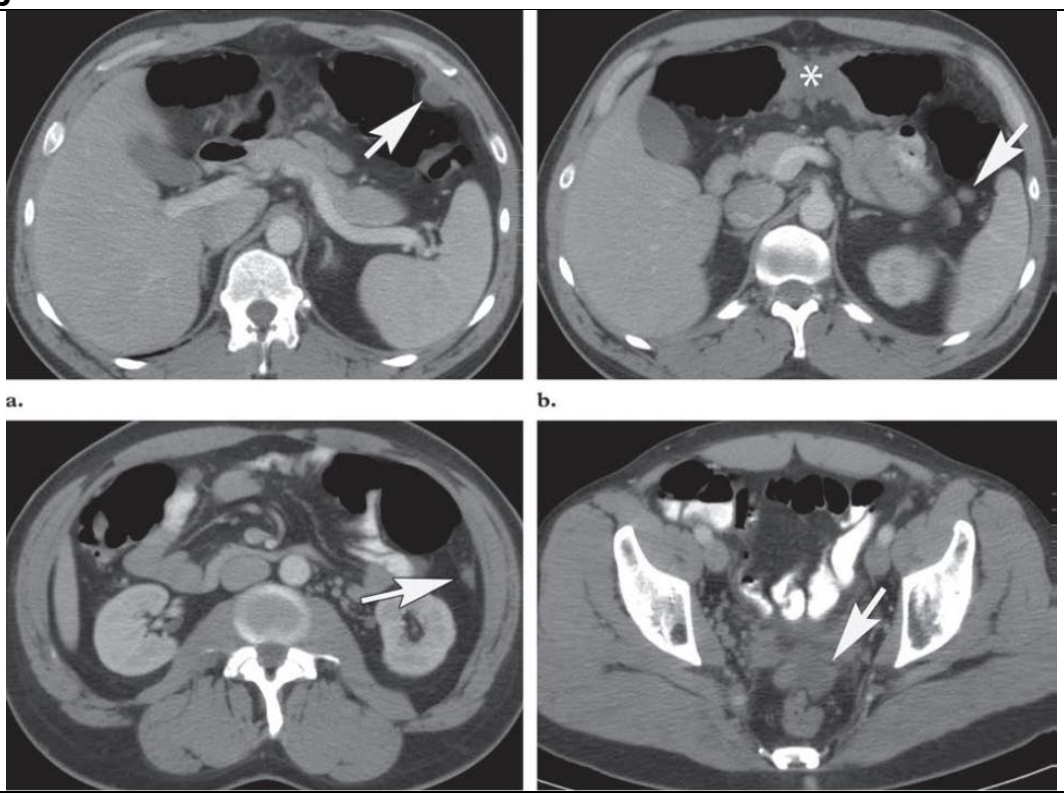
- CT sensitivity (85%–93%) but poor sensitivity (25%–50%) for detection of tumor implants less than 1 cm.
- MR sensitivity (85%–90%)
- FDG PET/ CT sensitivity 78%–100%.



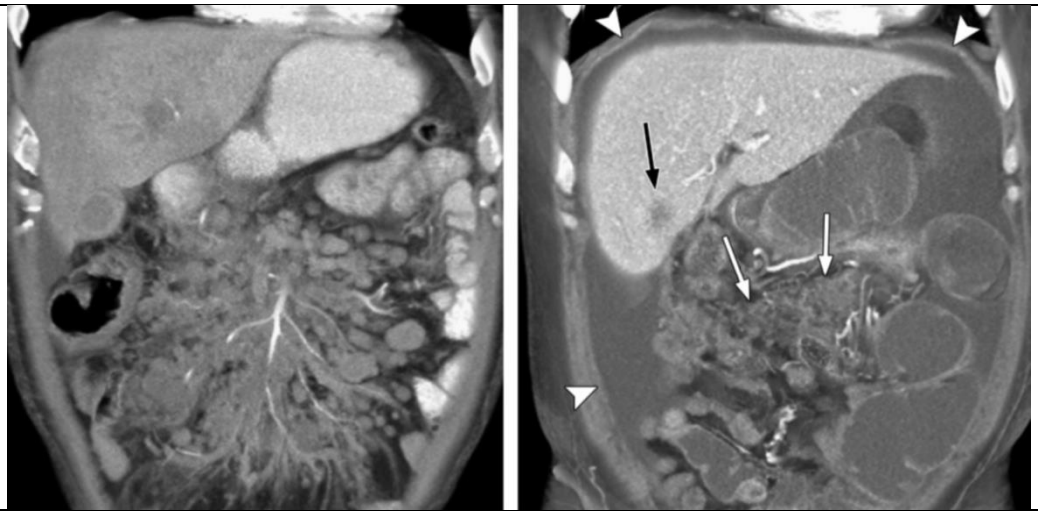
Metastatic ovarian carcinoma
Calcified masses in the mesentery and omentum



Multifocal Discrete Nodules



Diffuse Mesenteric Metastases



B-Pseudomyxoma Peritonei

- Pseudomyxoma peritonei (or jelly belly) describes the finding of copious, thick mucinous or gelatinous material on the surfaces of the peritoneal cavity.
- Rupture of a mucinous lesion of the appendix, ovary or other organs

Imaging Findings:

- Multi-loculated fluid collections
- Throughout the peritoneum, omentum and mesentery.
- Scalloping of visceral surfaces, particularly the liver
- Mass effect and distortion of bowel loops
- Scattered (curvilinear or punctate) calcifications may be frequently present
- CT: Low attenuation.
- T1: Low signal
- T2: High signal

C-Lymphoma

- Primary or secondary process.
- Nodal or extranodal NHL,
- such as small B-cell lymphoma, diffuse large B-cell lymphoma, and Burkitt lymphoma,
- may have secondary peritoneal involvement

Primary Peritoneal Lymphoma:

- Primary lymphomas of the peritoneum, also called body cavity– based lymphomas or primary effusion lymphomas,
- uncommon and nearly exclusively found in immunocompromised patients, most of whom are infected with HIV.
- associated with 2 viruses in the herpes virus family: human herpes virus 8 (HHV-8), which is also associated with Kaposi sarcoma, and Epstein-Barr virus

Secondary Peritoneal lymphomatosis

- Peritoneal enhancement and thickening + multifocal nodules and masses + Ascites + Omental caking+ infiltration of the small bowel mesentery=> mimic peritoneal carcinomatosis
- The presence of extensive adenopathy in lymph node chains typically involved with lymphoma, such as those in the retrocrural region and small bowel mesentery, may suggest lymphomatosis over carcinomatosis

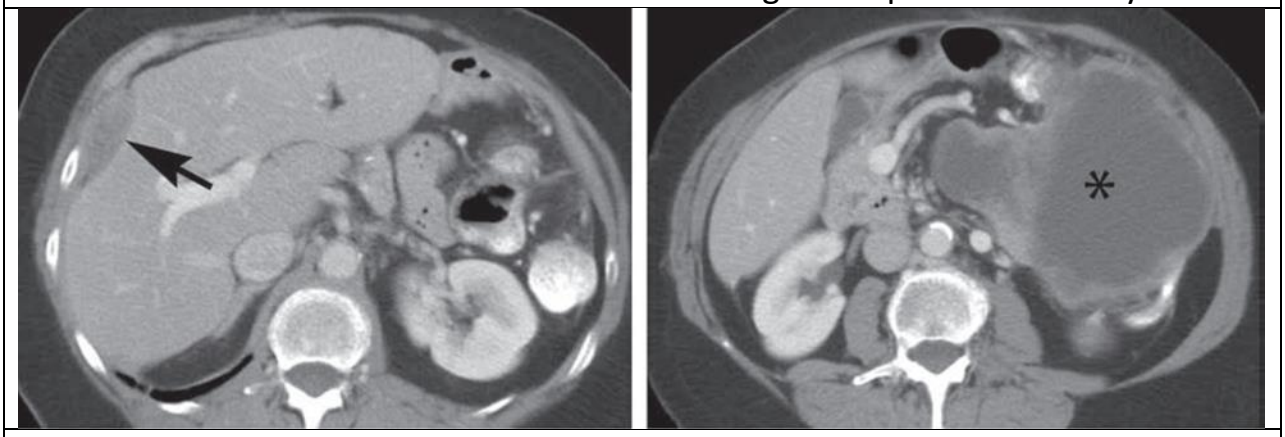
- Extensive and diffuse soft-tissue infiltration of the mesenteric fat.
- Omental caking

D- Sarcomatosis

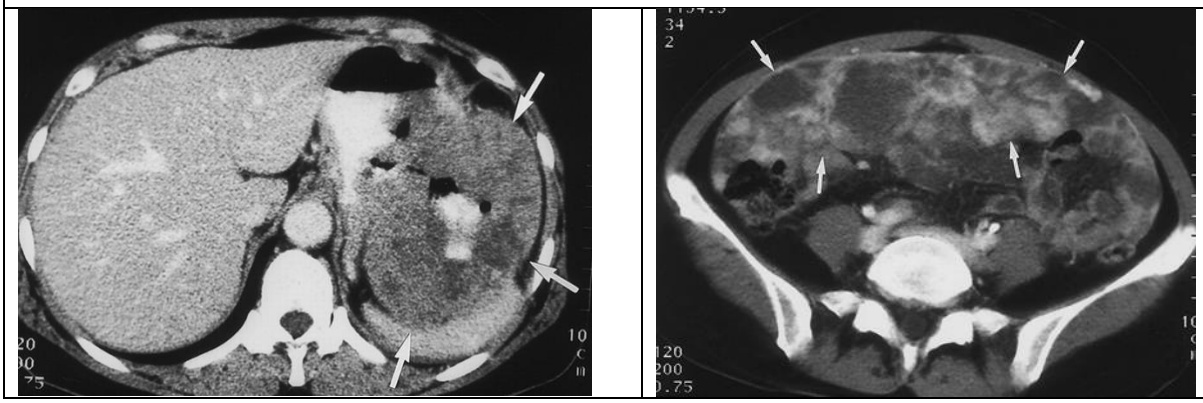
- are a heterogeneous group of malignant neoplasms that arise from tissue derived from primitive mesoderm.
- Metastasis to the peritoneal cavity from peripheral sarcoma termed peritoneal sarcomatosis, is unusual and is presumed to occur through a hematogenous route.

Malignant GIST:

- commonly spread to the peritoneum by extension of the tumor through the serosal surface of the bowel and direct seeding of the peritoneal cavity.



Gastric Leiomyosarcoma:



III- Sclerosing Peritonitis

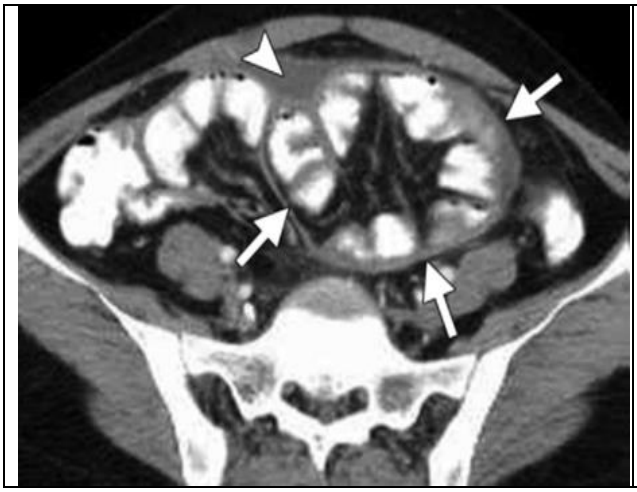
- is a condition marked by chronic fibrotic thickening of the peritoneum.

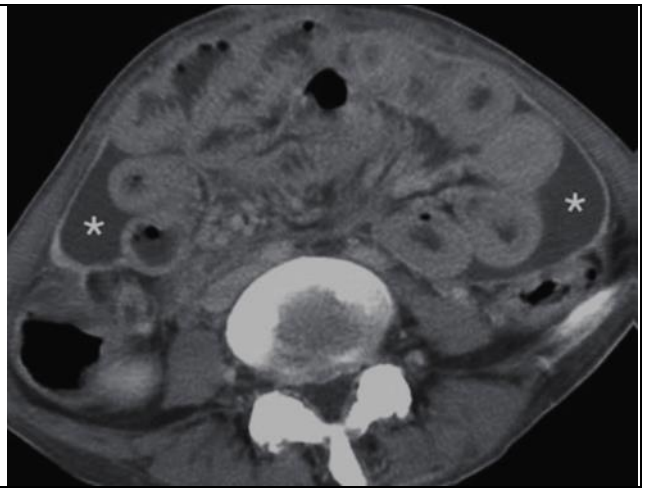
Risk factors:

- Idiopathic
- Chronic ambulatory peritoneal dialysis
- Peritoneo-venous or ventriculo-peritoneal shunts,
- Treatment with practolol.
- Tuberculosis, sarcoidosis, familial Mediterranean fever, gastrointestinal malignancy, protein S deficiency, liver transplantation, fibrogenic foreign material, and luteinized ovarian thecomas

Imaging Findings *=> Abdominal Cocoon*:

- Smooth thickening and enhancement of the peritoneum.
- Abnormal peritoneum encasing effects on the bowel.
- Peritoneal calcification, involving both parietal and visceral peritoneum.
- Encapsulation and clustering of the small bowel
- A loculated fluid collection is also seen.



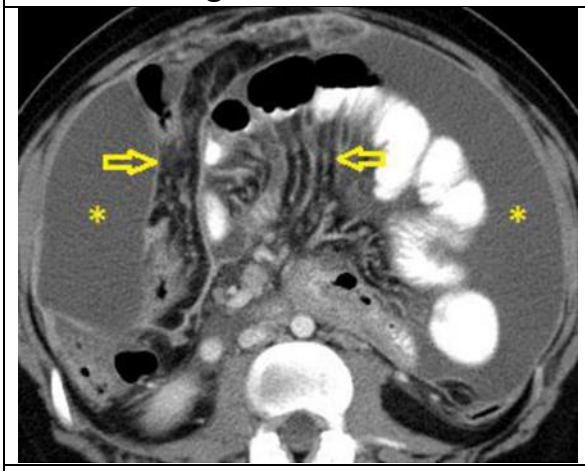


IV- Peritoneal TB

3 Types

Wet type

- Free or loculated
- High density ascites is thought to be due to high protein and cellular content.
- Peritoneal and mesenteric thickening and enhancement

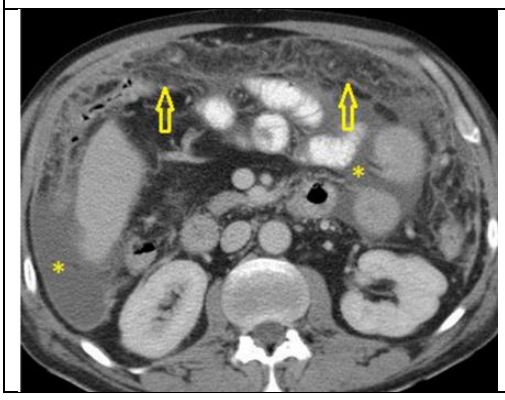


Dry type:

- Thickened ‘cake-like’ omentum
- Peritoneral and mesenteric thickening and enhancement
- Fibrous adhesions
- Caseous mesenteric lymphadenopathy

Fibrotic type

- Omental ‘cake-like’ mass
- Fixed bowel loops.
- Matted loops and mesentery
- Loculated ascites



Mesenteric Lesions

Primary Mesenteric Neoplasms:

- Desmoid Tumor
- Neurogenic Tumors
- Smooth muscle tumors and sarcomas

Secondary Mesenteric Tumors:

- Carcinoid Tumor
- Direct tumor infiltration from pancreatic, gastric, or colon cancer
- Peritoneal carcinomatosis
- Peritoneal lymphomatosis

Infectious / Inflammatory

- Granulomatous (TB) peritonitis
- Sclerosing Mesenteritis

Cystic

- Mesenteric cyst
- Cystic Mesothelioma
- Pancreatic pseudocyst / Non Pancreatic Pseudocyst
- Paraovarian cyst / Peritoneal inclusion cyst
- Seroma / Abscess / Hematoma
- Fetus in feto
- Teratoma

A- Desmoid Tumor

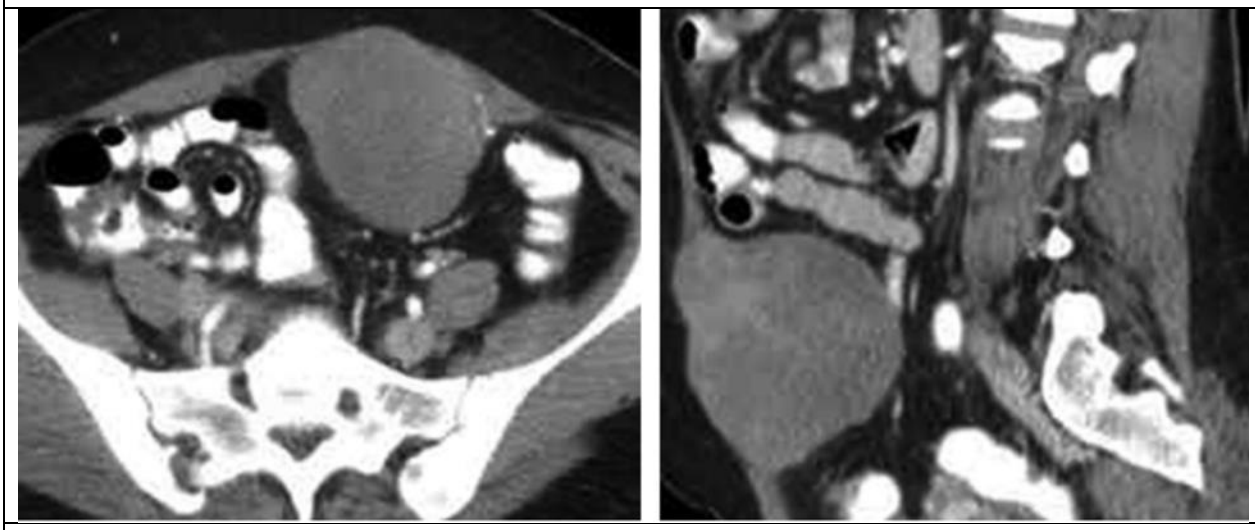
Classification of Fibromatoses

- Superficial (fascial)
  - Palmar fibromatosis (Dupuytren disease)
  - Plantar fibromatosis (Ledderhose disease)
  - Juvenile aponeurotic fibroma
  - Infantile digital fibromatosis
  - Penile fibromatosis (Peyronie disease)
- Deep (musculoaponeurotic)
  - Extraabdominal fibromatosis
  - Abdominal fibromatosis
    - Abdominal wall fibromatosis
    - Intraabdominal fibromatosis
      - Mesenteric fibromatosis
      - Retroperitoneal fibromatosis
      - Pelvic fibromatosis
  - Fibromatosis associated with Gardner syndrome
  - Infantile myofibromatosis
  - Fibromatosis colli

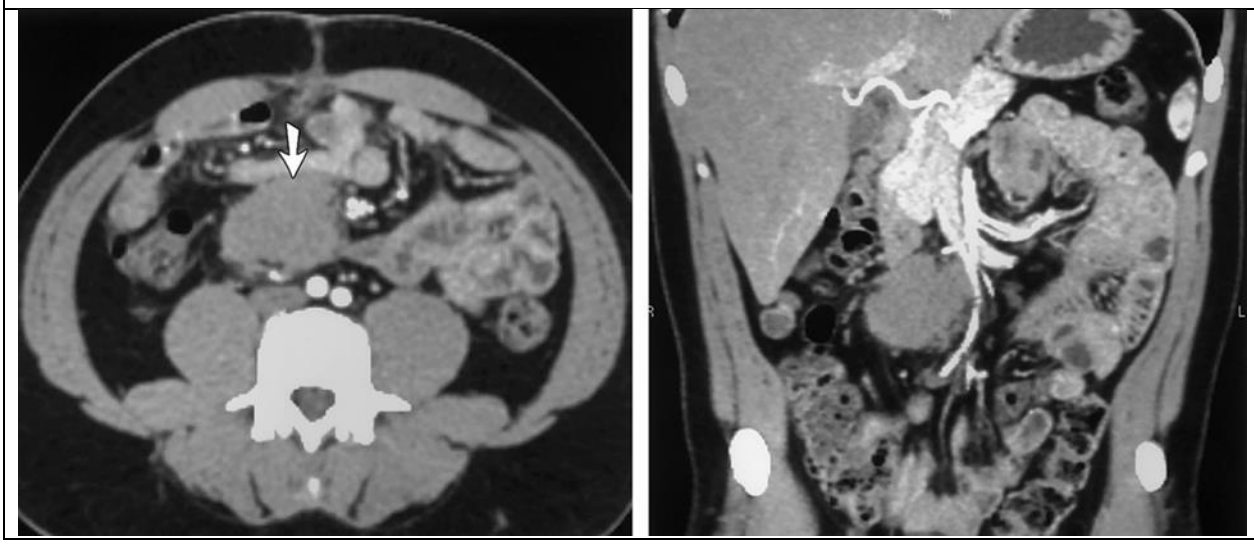
Imaging Findings:

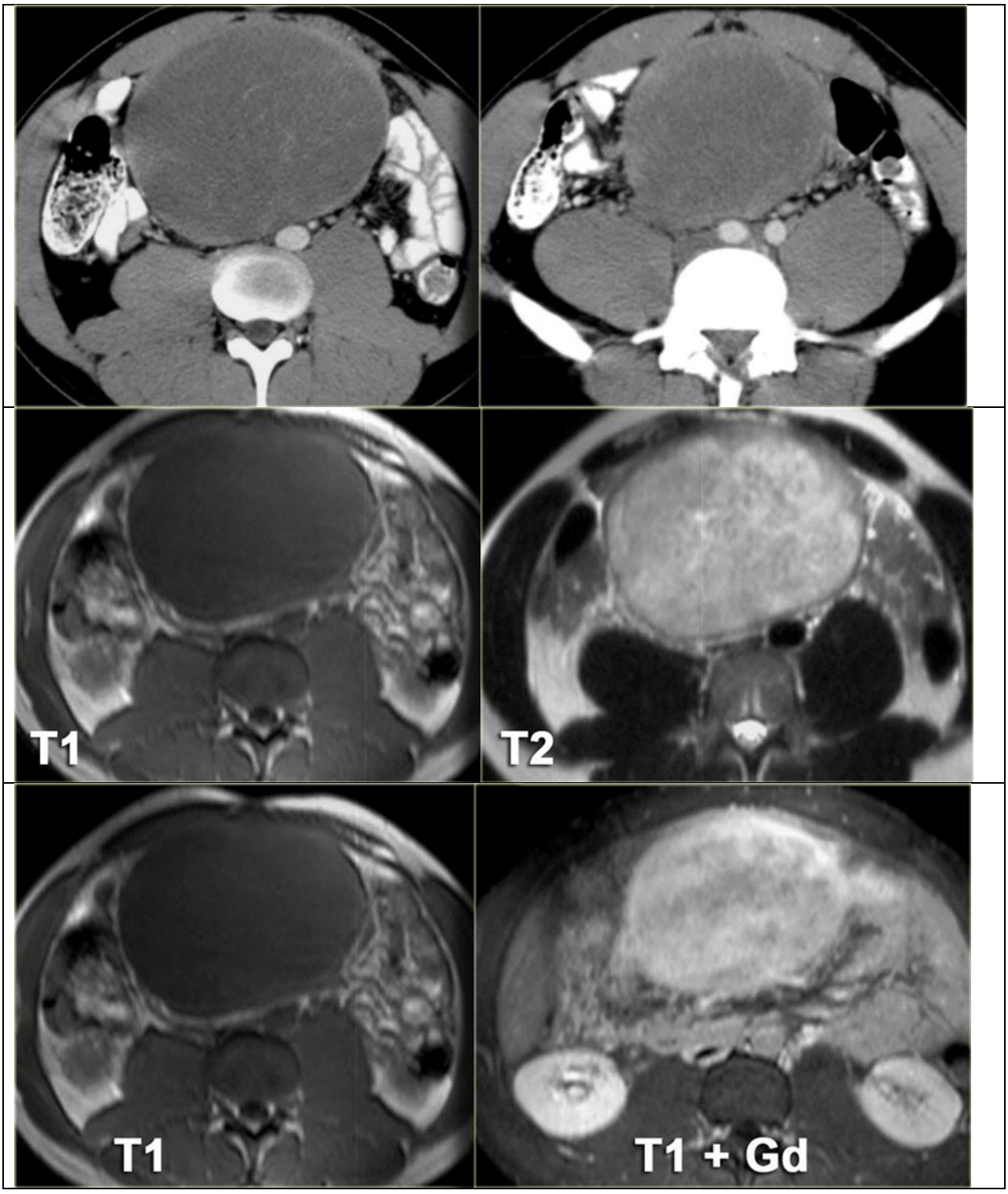
- Well defined Soft-tissue masses
- A “whorled appearance” of fibrosis growing into the mesenteric fat
- CT: Isoattenuating relative to muscle
- T1: low signal intensity
- T2: low signal intensity
- C+: may show homogeneous, inhomogeneous, or no significant enhancement

Abdominal Wall Desmoid Tumor



Mesenteric Desmoid Tumor




T1
T2
T1
T1 + Gd

B- Sclerosing Mesenteritis

- Spectrum of uncommon idiopathic chronic inflammatory mesenteric processes definitively diagnosed at pathologic review.

- 3 CT appearance reflects the dominant pathologic component:
  - Inflammation => Mesenteric Panniculitis
  - Fat Necrosis => Mesenteric Lipodystrophy
  - Fibrosis => Retractile Mesenteric Fibrosis

i) Mesenteric Panniculitis:

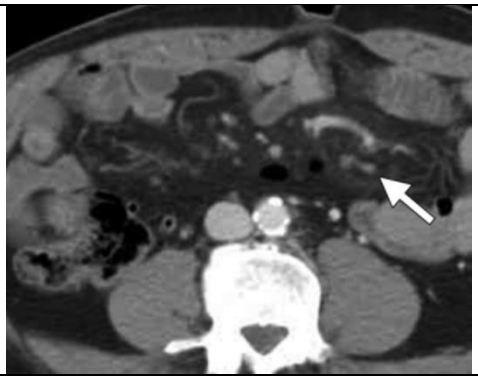
- When the inflammation predominates. Present with acute pain.

"Misty mesentery"

- Focal area of increased attenuation within the mesenteric fat
- Small mesenteric nodes
- Areas of fibrosis within the inflamed fat appear as linear bands

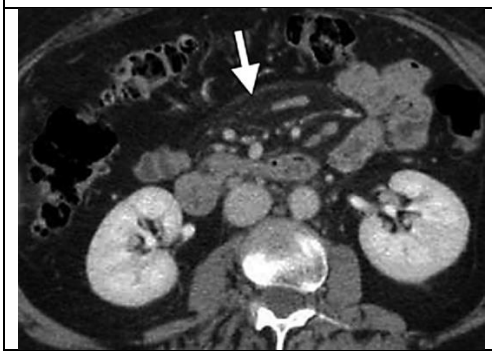
Fat-ring sign

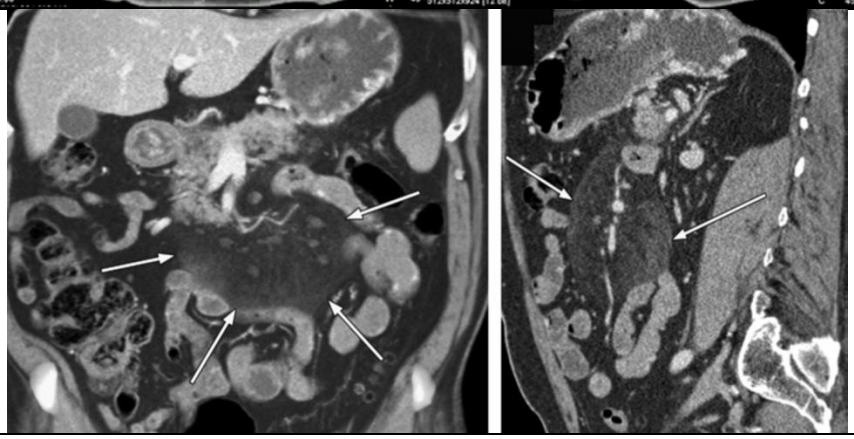
- Preservation of fatty attenuation, in the form of a low-attenuation halo, around the vessels of the involved mesentery



Tumoral Pseudocapsule

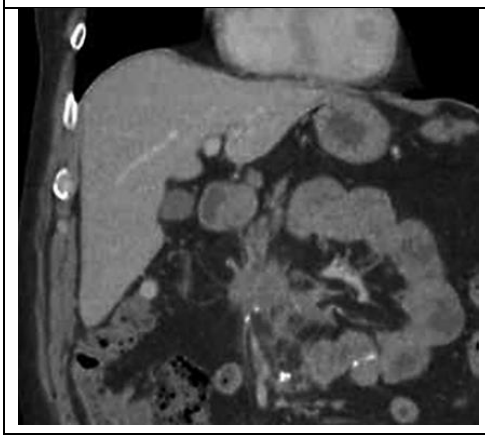
- A band of soft-tissue attenuation surround the affected mesentery





ii) Retractile Mesenteritis:

- Chronic form
- Fibrosis predominates
- Large masses of soft-tissue attenuation that may contain calcifications.
- Some masses are poorly defined, with whiskers of soft tissue thickening extending into the adjacent fat.
- Involvement of parenchymal organs such as the pancreas has been described.
- Cannot be distinguished from a carcinoid tumor or lymphoma without extensive histologic sampling or Indium-111 Octreotide scintigraphy

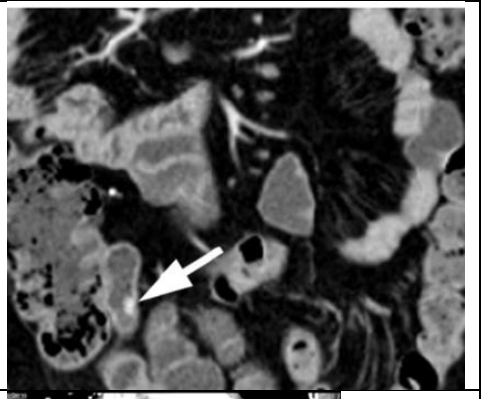
Mesenteric Root Mass Desmoplastic response and speculation in relation to the mass	Calcification
	

C- Mesenteric & Midgut Carcinoid

- 2nd most-common small bowel malignancy after adenocarcinoma
- Most common location is the distal ileum.

1ry lesion:

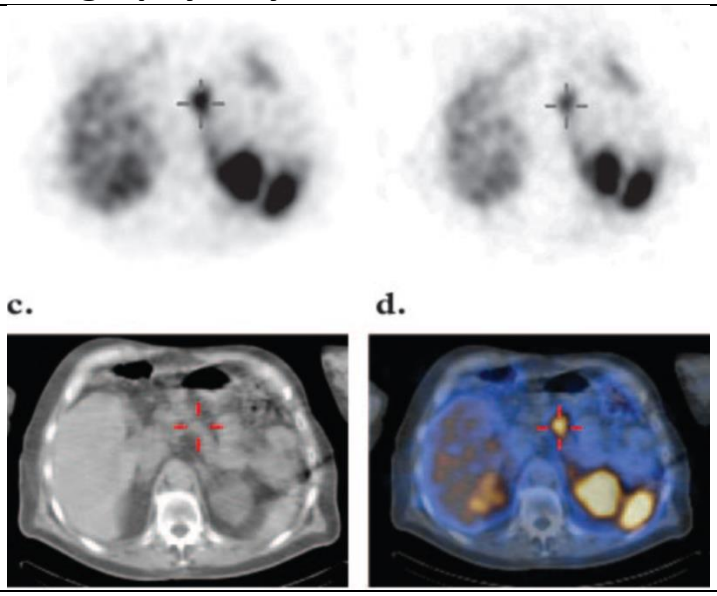
- Terminal ileum
- Sumucosal
- Intraluminal
- Small < 2cm
- Well defined
- Polypoidal
- Intense arterial enhancement



Mesenteric Nodal Mass

- Speculated mesenteric mass
- Calcification
- Desmoplastic reaction
- Vascular encasement
- Bowel ischemia =Dilated lumen + thickened wall

Octreotide Scintigraphy + hybrid SPECT/CT



Peritoneal & Mesenteric Cystic Lesions

- **Mucinous Carcinomatosis**
- **Multicystic Mesothelioma**
- **Pseudomyxoma peritonei**
- **TB Peritonitis**

- **Mesenteric cyst:**
  - **Lymphangioma**
  - **Mesothelial cyst**
  - **Enteric and Enteric duplication cyst**
  - **Non Pancreatic Pseudocyst**

- **Teratoma**
- **Fetus in fetu**

- **Meconium Cyst**
- **Pancreatic pseudocyst.**

- **Seroma / Abscess / Hematoma**

Nonovarian Cystic Lesions of the Pelvis

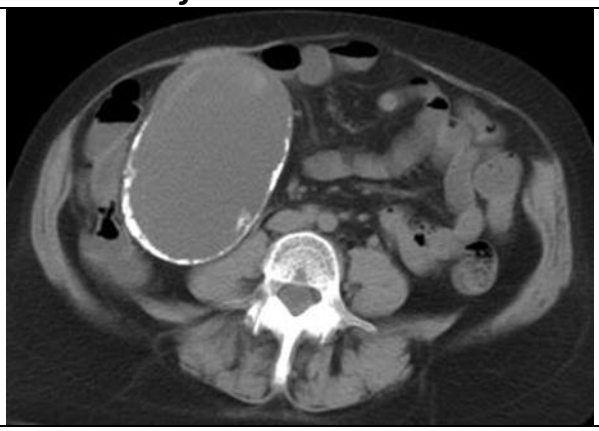
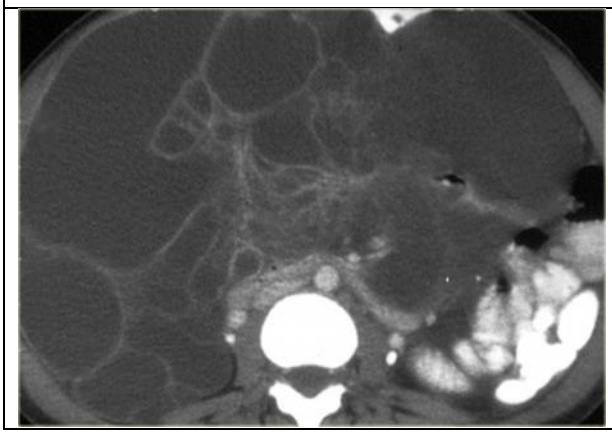
Location	Type of Cyst
Intraperitoneal	
Peritoneum	Peritoneal inclusion cyst, paraovarian cyst
Appendix	Appendiceal mucocele (retention cyst, mucosal hyperplasia, cystadenoma, cystadenocarcinoma)
Fallopian tubes	Hydrosalpinx, hematosalpinx, pyosalpinx
Uterus	Degenerating leiomyoma, cystic adenomyosis, unicornuate uterus with an obstructed horn
Extraperitoneal	
Presacral space	Spinal meningeal cyst, retrorectal cyst
Vascular and lymphatic system	Lymphocele, cystic degeneration of lymph nodes, pelvic lymphangioleiomyomatosis, cystic lymphangioma, pelvic hemangioma
Both intra- and extraperitoneal	Pelvic abscess, hematoma, bladder diverticulum

1) Mesenteric Cyst

- Mesenteric cyst is a descriptive term for any cystic lesion within the mesentery.

Aetiology

- Lymphatic: simple lymphatic cyst and **lymphangioma** (Most common)
- Mesothelial: simple mesothelial cyst, benign cystic mesothelioma, and malignant cystic mesothelioma
- Enteric: enteric cyst and enteric duplication cyst
- Non-pancreatic pseudocysts (infectious and traumatic cysts)

Simple Cyst	***Mural Calcifications***
	
Lymphangioma: Multilocular cystic lesion with enhancing septations	**Nonpancreatic pseudocyst:** Residual of an old hematoma or infection. Most of these patients have a history of prior abdominal trauma. Thickened wall + debris within the lesion.
	

2) Enteric Duplication Cyst

- Gastrointestinal tract duplication cysts are rare congenital gastrointestinal malformation in young patients and adults.

Types & Location

- Foregut duplication cysts:
  - Esophageal
  - Bronchogenic
  - Neuroenteric
- Small bowel duplication cysts:
  - Duodenal (6%)
  - Jejunal (50%)
  - Ileal (44%)
- Large bowel duplication cysts:
  - Colonic
  - Tail gut cyst

Clinical picture:

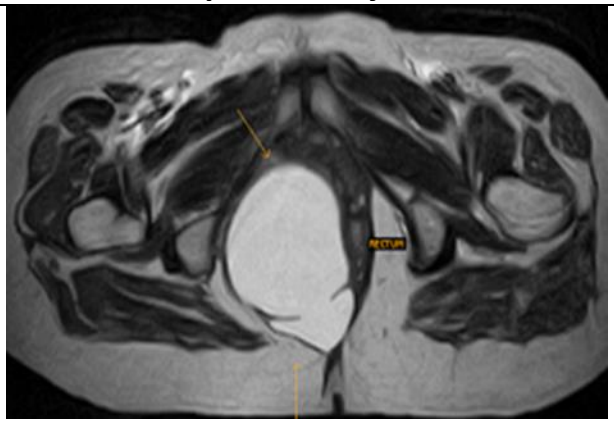
- Asymptomatic
- Abdominal pain and vomiting
- Intussusception

Histology:

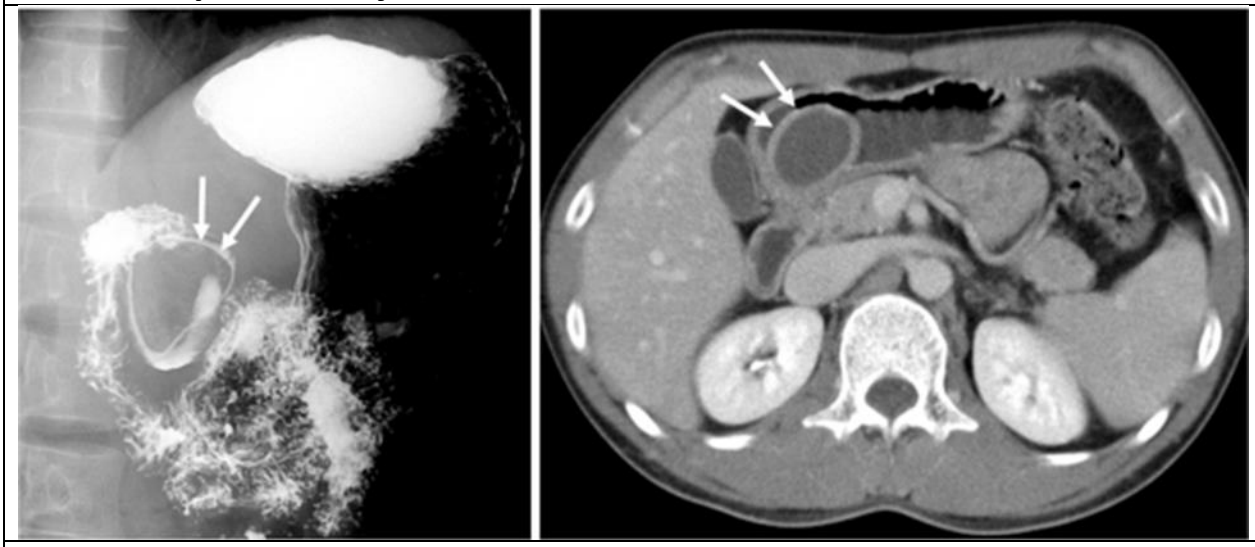
- Enteric duplication cyst is a cyst with a wall that has all three layers of the bowel wall, i.e. mucosa, submucosa and muscularis propria.

Imaging findings:

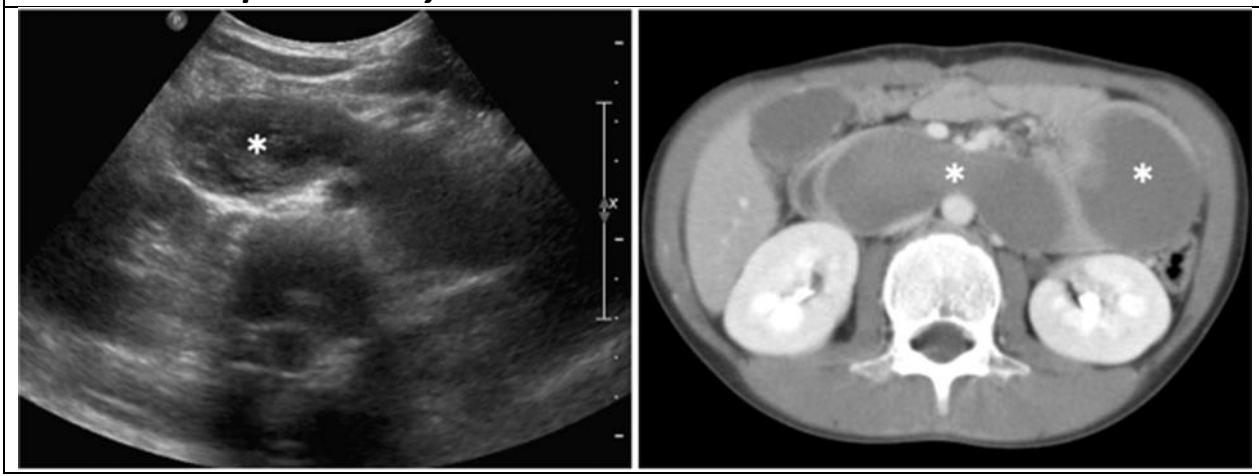
- Well defined cyst
- May contain debris
- Calcifications (rare)
- CT: Low attention
- T1: Low signal
- T2: High signal
- +C: No enhancement

Ileocecal Enteric Duplication Cyst	*Perirectal Duplication Cyst*
	

Gastric duplication cyst



Duodenal duplication cyst



3) Peritoneal Inclusion Cyst

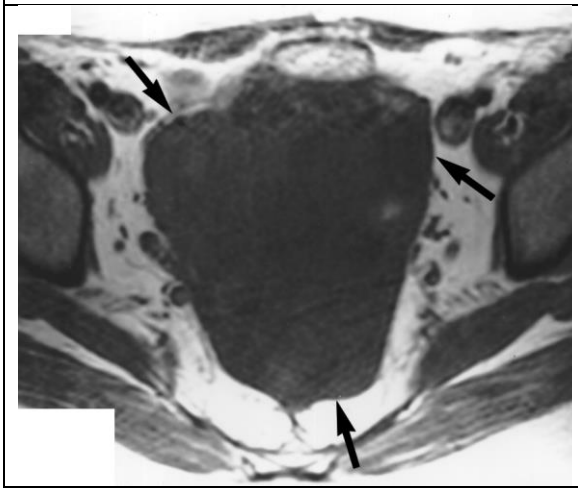
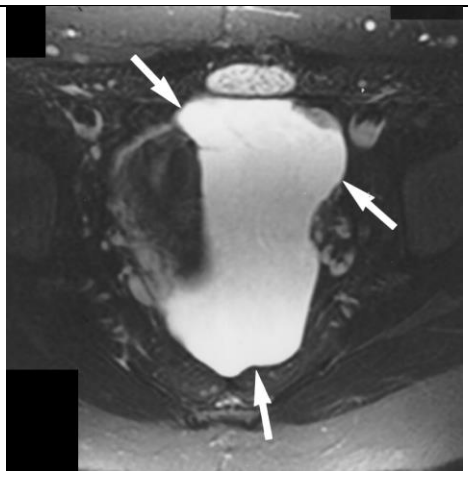
- Pathophysiology:
- The normal peritoneum absorbs fluid easily.
- Peritoneal fluid is predominantly formed by exudation from an active ovary.
- However, when the peritoneum becomes infected or mechanically injured, its transport properties are changed and fluid absorption is slower, causing a decrease in the clearance of ovarian fluid.
- Additionally, inflammation may cause exudate.
- Peritoneal inclusion cysts represent a nonneoplastic reactive mesothelial proliferation.
- Peritoneal fluid accumulation within adhesions appears as on sonography.

Spider Web Pattern (Entrapped Ovary)

- Peritoneal inclusion cysts are adherent to the surface of the ovary but do not involve the ovarian parenchyma
- The entrapped ovary appears like a spider in a web

Imaging Findings:

- Complex multicystic adnexal lesion
- No true walls
- CT: Low attenuation
- T1: Low signal
- T2: High signal
- +C: No enhancement

Axial T1	Axial T2 FS
	

4) Mesenteric Teratoma

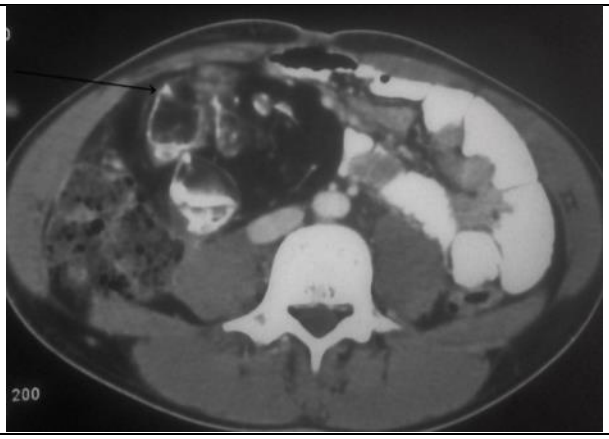
- Teratomas arise from totipotent primordial cells, present in the midline.
- These display mixture of tissues of tridermal or bidermal origin, foreign to anatomic site
- It is seen in young population

Location:

- Sacrococcygeal area (47.2%)
- Gonads (31.6%)
- less frequently at other sites
- Rarely in the mesentery

Imaging findings:

- Well defined lesion
- Fat
- Cystic spaces due to mucous production or other exocrine products
- Rokitansky nodule or Dermoid plug refers to a solid protuberance
- Calcification including teeth

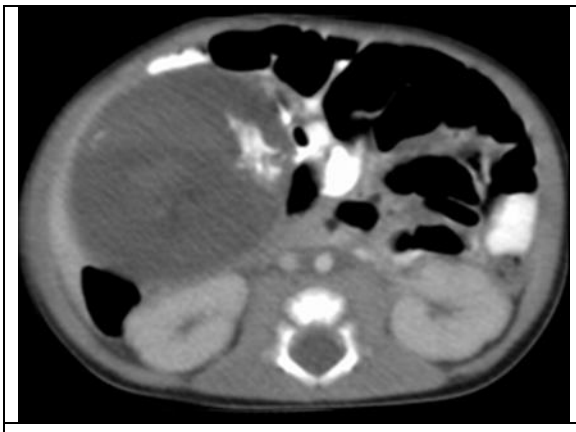


5) Fetus-in-fetu (FIF)

- is an extremely rare abnormality that occurs secondary to abnormal embryogenesis in a monochorionic diamniotic pregnancy where a non-viable fetus becomes enclosed within a normally developing fetus.

Location

- Most occur in the abdomen / retroperitoneal cavity.
- Other reported locations include.
    - Cranial cavity
    - Mediastinum
    - Scrotum



Spin: -0
Tilt: -90
F

Spin: -0
Tilt: -0
A

Acute Abdomen

❖ Causes of Acute Abdominal Pain

1. **Pregnancy related**
   - Spontaneous abortion
     - Threatened
     - Complete
     - Incomplete
     - Septic
   - Ectopic pregnancy

2. **Gynecologic: infectious**
   - Endometritis
   - PID/salpingitis
   - TOA

3. **Gynecologic: noninfectious**
   - Dysmenorrhea
   - Uterine fibroids
   - Endometriosis
   - Mittelschmerz (midcycle ovulatory pain)
   - Ovarian cysts
     - Rupture
     - Hemorrhage
     - Torsion
   - Ovarian cancer/tumor
   - Ovarian hyperstimulation syndrome

4. **Nongynecologic**
   - Gastrointestinal
     - Appendicitis
     - Gastroenteritis
     - Diverticulitis
     - Inflammatory bowel disease
     - Irritable bowel syndrome
     - Bowel obstruction
     - Mesenteric lymphadenitis
     - Constipation
     - Abdominopelvic adhesions
   - Urinary tract
     - Lower urinary tract infection/cystitis
     - Interstitial cystitis
     - Pyelonephritis
     - Nephrolithiasis
   - Musculoskeletal
     - Strained tendons/muscles
     - Joint infection/inflammation
     - Hernia
   - Other
     - Aortic aneurysm
     - Aortic dissection
     - Porphyria

Diverticulitis

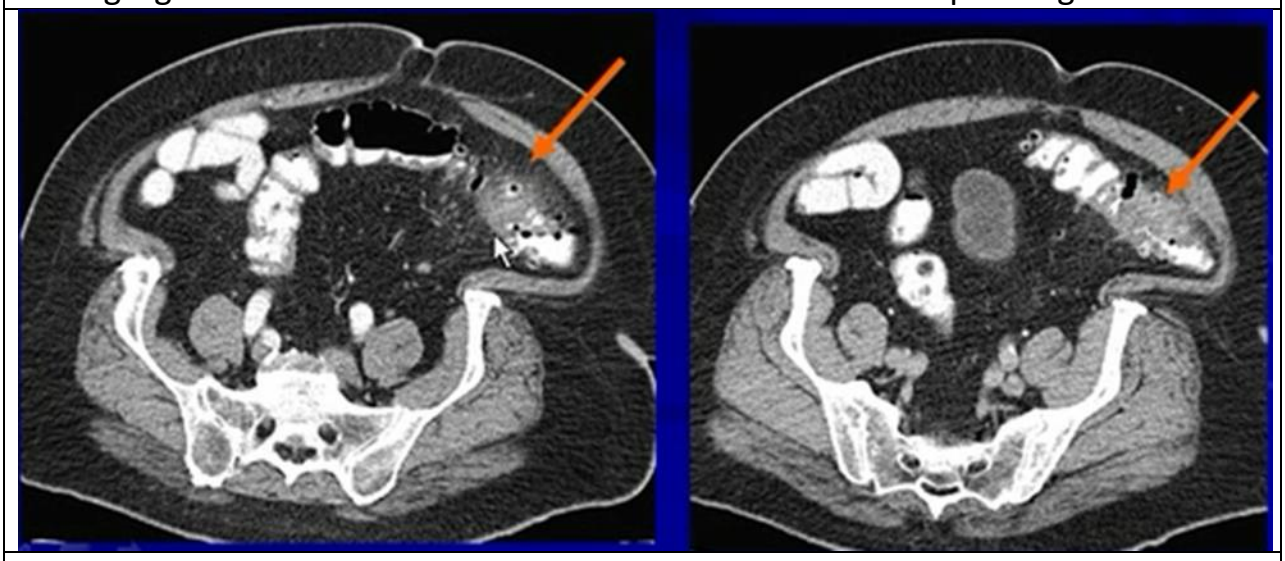
- Colonic diverticulosis is a very common condition in Western society,
- 5%–10% over 45 years
- 80% over 85 years of age.
- The most common location for diverticula is the sigmoid colon.

i. Diverticulosis:

- Colonic outpouching of mucosa and submucosa through the muscularis of the colonic wall between the teniae coli and mesentery.
- CT: Small, air-filled outpouchings of the colonic wall
- T1WI: Diverticula appear hypointense against the high-signal of pericolonic fat

ii. Acute Diverticulitis

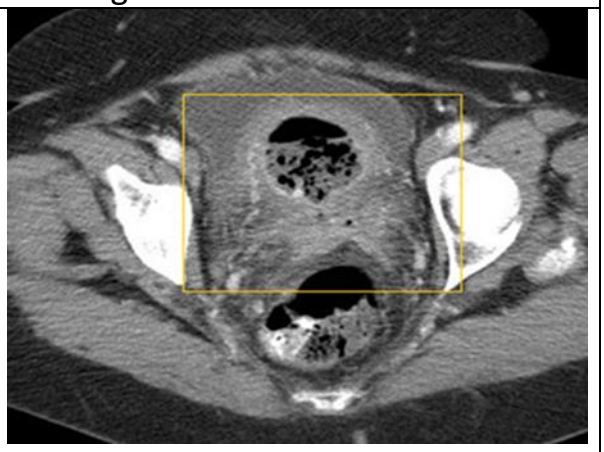
- Neck of diverticulum is occluded by food particles, stool, or inflammation.
- Paracolic fat stranding
- Focal colonic wall thickening.
- Thickening of the lateral conal fascia
- Small amounts of ascites in the cul-de-sac.
- Accumulation of fluid in root of the sigmoid mesentery " comma sign"
- Engorgement of the mesenteric vessels is called the "centipede sign"



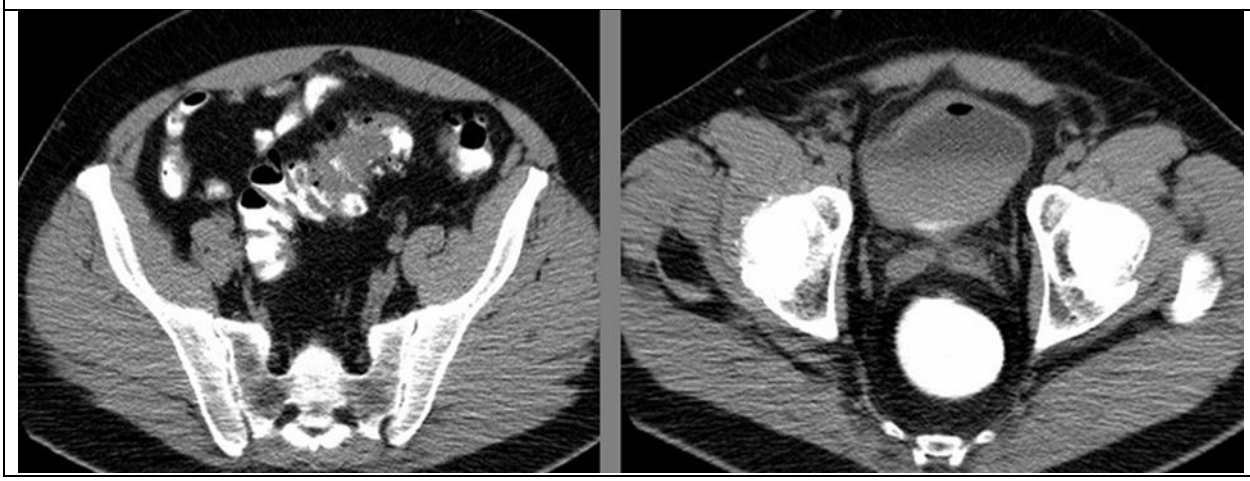
iii. Complicated Diverticulitis:

- Microperforation of the diverticulum and surrounding mild pericolic inflammation, which is usually contained by pericolonic fat and mesentery.
- Diverticular abscess
- Colovesical fistula

- **An abscess:** a hypodense fluid collection with a contrast-enhancing rim and surrounding inflammatory changes. It may contain air or air–fluid levels.
- **A colovesical fistula:** is suspected when air is seen in the bladder and there is thickening of the bladder wall adjacent to a diseased segment of bowel.
- **Perforations:** appear as small extraluminal deposits of air or extravasation of oral contrast material.
- **Pneumoperitoneum** is a rare finding in patients with diverticulitis

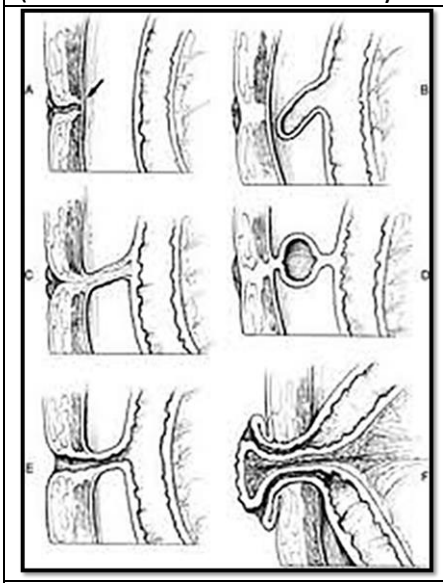
Perforation: Extra-luminal air	Colovaginal Fistula
	

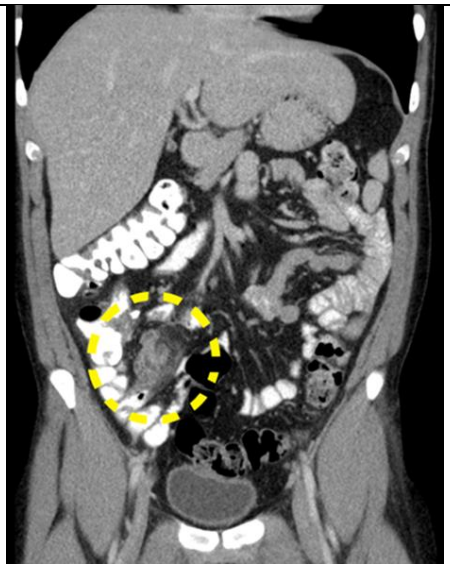
Colovesical Fistula:
Rectal contrast without IV contrast in the bladder



Acute Meckel's Diverticulitis

A vestigial remnant of the **omphalomesenteric duct**
(also called vitelline duct or yolk stalk).





Role of 2:

- 2 inches long.
- 2 feet from end of ileum.
- 2-4 times more common in men.
- 2% occurrence in population.
- 2% of cases are symptomatic
- usually presents among children at the age of 2
- 2 types of ectopic tissues (gastric and pancreatic)

Imaging findings:

- Meckel's diverticula are round or tubular fluid/air filled structures communicating with small bowel with a wall-to-wall diameter of 1.5-6 cm.
- Mural wall thickening and enhancement is seen with surrounding inflammatory changes in the adjacent fat as well as small reactive mesenteric lymph nodes.
- Wall enhancement will be absent in gangrenous Meckel's diverticulum.

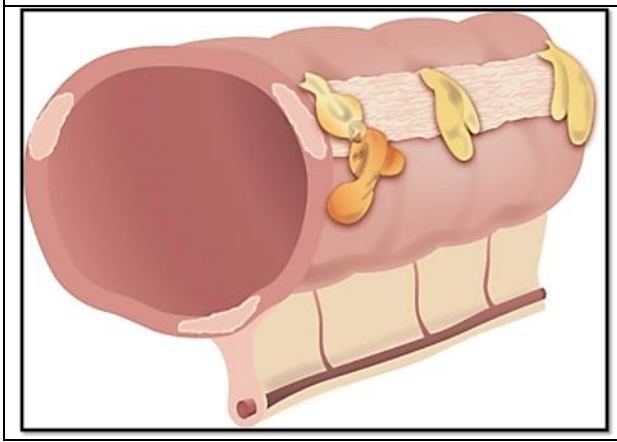
Technetium-99m (99mTc) Pertechnetate scan

- is the investigation of choice to diagnose Meckel's diverticula in children.
- This scan detects ectopic gastric mucosa; since approximately 50% of symptomatic Meckel's diverticula have ectopic gastric or pancreatic cells contained within them.
- In children, this scan is highly accurate and noninvasive, with 95% specificity and 85% sensitivity.
- In adults the test is only 9% specific and 62% sensitive

Epiploic Appendagitis

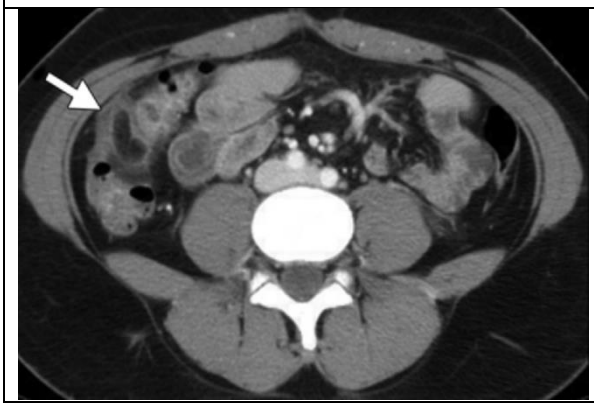
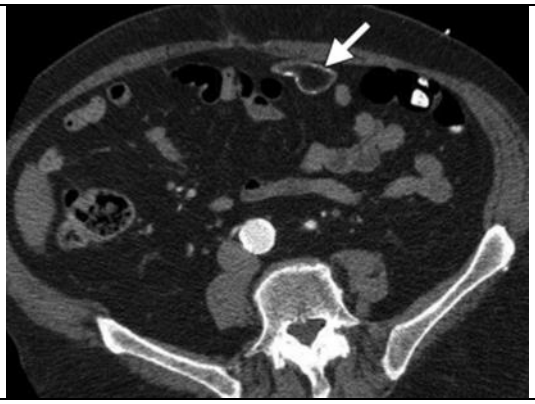
- Appendices epiploicae are pedunculated fat filled structures protruding from the external surface of the colon into the peritoneal cavity.
- Epiploic appendagitis, also known as hemorrhagic epiploitis or appendicitis epiploica, is a rare benign self-limiting pathology secondary to torsion or spontaneous venous thrombosis of a draining vein.
- Age: 2^{nd} – 5^{th} decades of life
- M=F
- In obese persons and people who have recently lost weight.
- The average length is 3 cm, although they are occasionally up to 15 cm in size

❖ Normal Epiploic appendages

Small outpouchings of visceral peritoneum that contain fat and small blood vessels and arise from the serosal surface of colon adjacent to the tenia coli in the colon	Pedunculated fat structures, which protrude from the sigmoid surface into the peritoneal cavity (arrow).
	

Imaging findings:

- An oval-shaped fingerlike paracolic mass with the attenuation of fat.

Rimlike Zone	Central dot sign
A hyperattenuating rim that surrounds the lesion and represents the inflamed visceral peritoneal lining 2-3mm thickness	A high-attenuation central dot is attributed to thrombosis of the central vein
Periappendiceal fat stranding Fat stranding surrounding a fatty ovoid structure.	**Calcified Avulsed Freely mobile Epiploic Appendage**
	

Omental Infarction

- Although most cases are idiopathic, a small fraction of cases have been associated with prior surgery
- Usually occurs in young or middle-aged adults,
- Typically present with acute lower abdominal pain.
- Its clinical manifestation mimics that of other causes of acute lower abdominal pain such as acute appendicitis and diverticulitis.
- Commonly involves the right aspect of the omentum, since this is the most mobile segment of the omentum and the portion that is richest in fat.

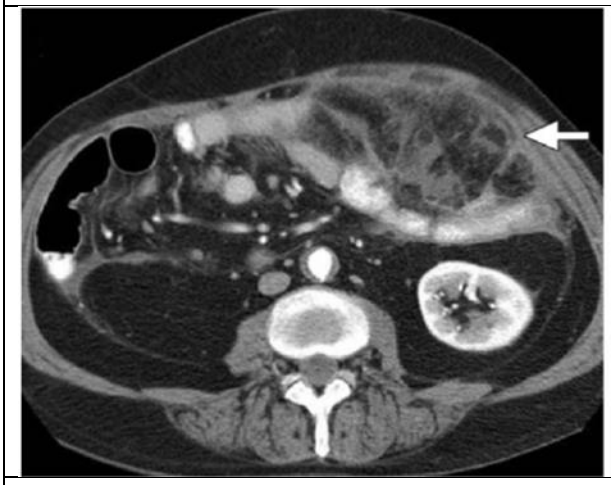
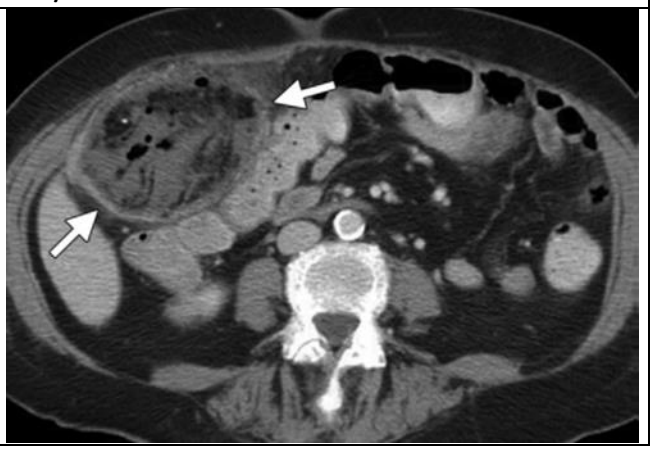
- **Primary omental infarction** is typically seen in pediatric patients and is associated with a bifid omentum, accessory omental tissue, or variant vascular supply.
- **Secondary omental infarction** is more common overall than primary omental infarction and is associated with postoperative omental adhesions, an omental mass, and trauma

Imaging findings:

- No central dot sing / No rim like zone (DD: Epiploic Appendagitis)

- Focal fatty mass + heterogeneous fat attenuation Soft tissue stranding
- Large > 5cm
- Deep to the anterior abdominal wall
- Anterior to colon

Right lower quadrant of abdomen	Left lower quadrant of abdomen

Omental infarction with extensive inlammation	Omental infarction with liquefactive necrosis
	
Omental Infarction with Torsion	Infected Omental Infarction Rim enhancement Fat/Fluid level + Air loculi
	

Gossypiboma

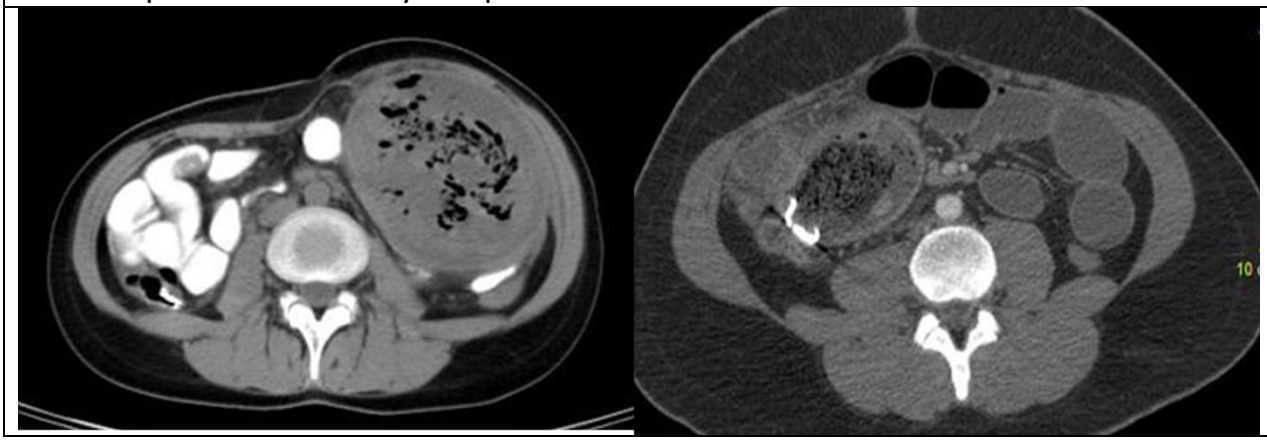
- A gossypiboma (textiloma1 or cottonoid) are terms used to describe a foreign object, such as a mass of cotton matrix or a sponge, that is left behind in a body cavity during an operation. It is an uncommon surgical complication.
- The manifestations and complications of gossypibomas so are variable that diagnosis maye be difficult and patient morbidity is significant.

Location:

- Intrathoracic
    - Pleural cavity
    - Pericardial cavities
- Abdominal cavity

Imaging findings:

- Spongiform appearance with gas bubbles
- Low-density mass with a thin enhancing capsule
- calcifications deposited along the network architecture of a surgical sponge
- A sponge left within the pleural space shows no gas lucencies due to resorption of the air by the pleura.



GIT Bleeding

Silent Vs Overt:

- Silent may manifest as amounts of blood detectable only with chemical tests in the stool or as iron deficiency anemia.
- Overt is high-volume bleeding manifesting as hematemesis, melena, or hematochezia

Upper Vs Lower:

- Upper GI bleeding occurs proximal to the ligament of Treitz (which connects the fourth portion of the duodenum to the diaphragm) and arises from the esophagus, stomach, or duodenum.
- Lower GI bleeding occurs distal to the ligament of Treitz and involves the small bowel, colon, or rectum.

Imaging Modalities:

- ***CT enterography and CT enteroclysis (See Bowel before)***
- ***CT angiography***
- ***Radionuclide imaging.***
- ***Catheter-directed angiography.***
- ***Wireless capsule endoscopy.***
- ***Double-balloon enteroscopy.***

❖ *Aetiology*

Upper GI lesions

- Cameron erosions
- Fundic varices
- Peptic ulcer
- Angiectasia
- Dieulafoy lesion
- Gastric antral vascular ectasia

Middle GI lesions

- In patients <40 years of age
  - Tumors
  - Meckel diverticulum
  - Dieulafoy lesion
  - Crohn disease
  - Celiac disease
- In patients >40 years of age
  - Angiectasia
  - NSAID* enteropathy
  - Celiac disease
- Uncommon lesions
  - Hemobilia
  - Hemosuccus pancreaticus
  - Aortoenteric fistula

Lower GI lesions

- Angiectasia
- Neoplasms

A- CT Angiography

Aim:
Identification of the Bleeding Cause:

Advantages:

- NON invasive technique
- Rapid technique
- Sensitivity for low rates of bleeding (0.5 mL/min)

Patient preparation

- Fasting 4 hours before the examination

Oral Contrast:

- NO prior oral administration of water or contrast material.
- Intraluminal water lead to dilution of extravasated contrast agent, leading to false-negative results.

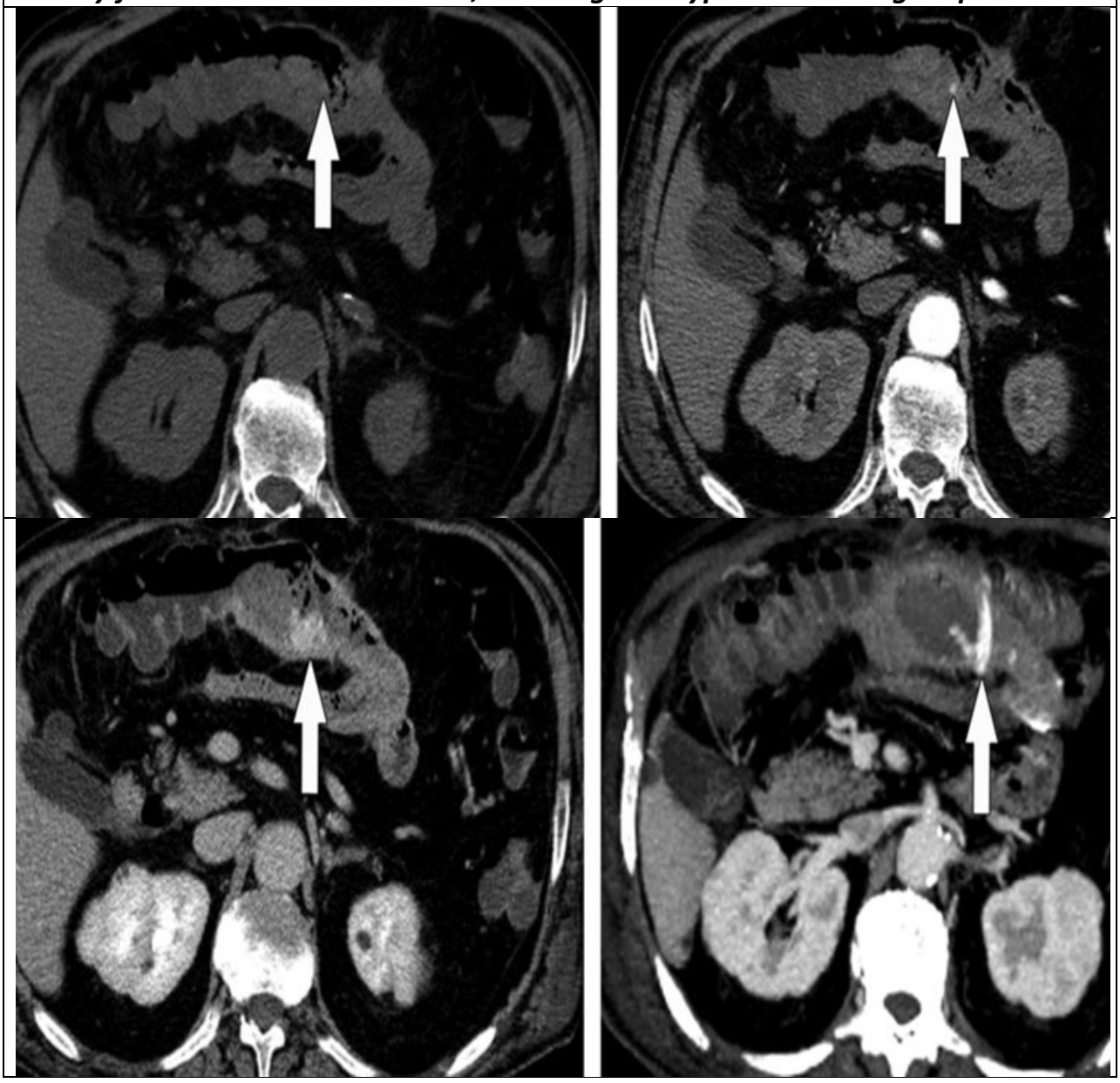
IV Contrast:

- Type : iodinated contrast material
- Amount = 150 mL
- Rate = 4 mL/sec
- Site = antecubital catheter,
- Bolus triggering is performed by placing a region-of-interest cursor over the descending aorta 2 cm above the diaphragm.
- ROI trigger threshold is set at 150 HU.

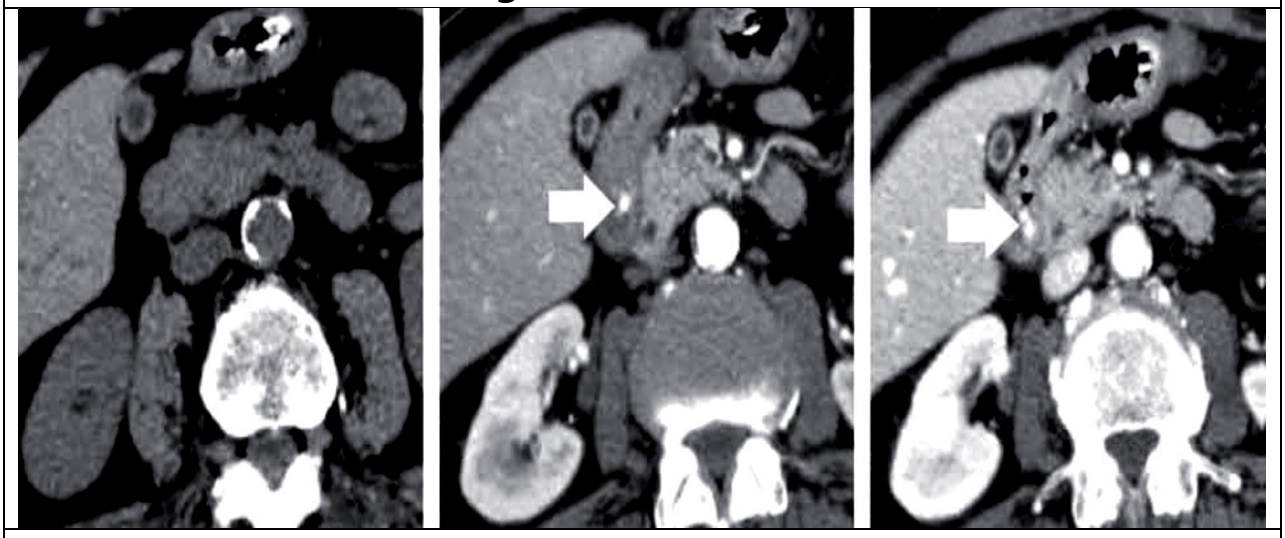
Scanning Phases:

- Scanning is performed from the diaphragm to the symphysis pubis during each of 3phases:
    - Unenhanced CT
    - Arterial phase: 20–25 seconds
    - Enteric phase: 45 sec
    - Delayed phase: 70–75 seconds
- Section thickness = 2.0 –2.5 mm
- Reconstruction interval = 1.0 –1.5 mm.

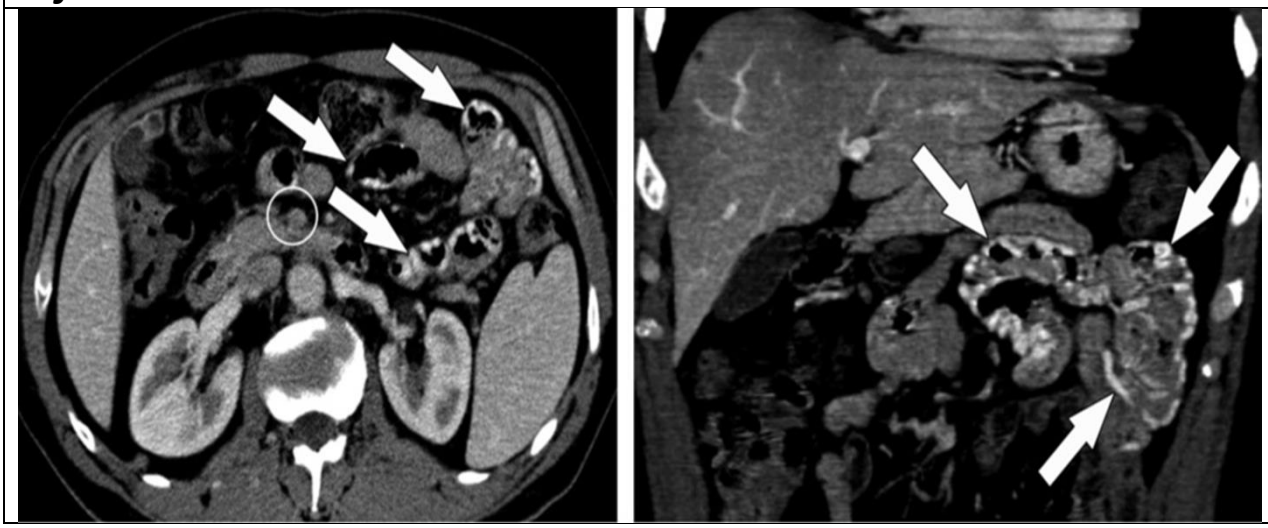
The extravasation of contrast material may demonstrate:
Linear, jetlike, swirled, ellipsoid, or pooled configuration,
or may fill the entire bowel lumen, resulting in a hyperattenuating loop.



Active duodenal bleeding



Jejunal Varices



B- Radionuclide Imaging

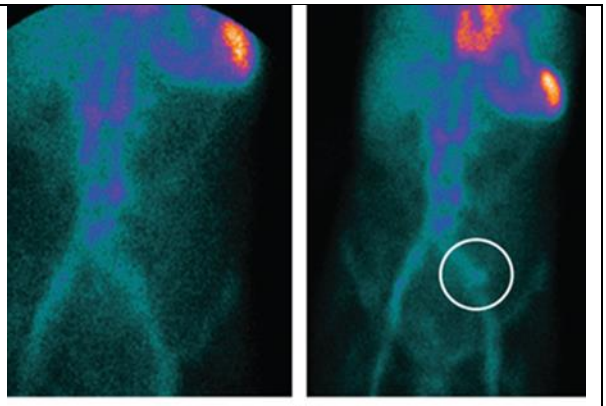
- Scintigraphy of GI bleeding is most commonly performed with technetium 99m (99mTc)–labeled red blood cells (RBCs); this technique allows acute and delayed imaging owing to the persistence of labeled RBCs in the circulation.
- Tagged RBC scanning is considered to be the standard of reference for detection of active lower GI bleeding.

Advantages:

- ***Most sensitive technique allows detection of active bleeding at rate of 0.10mL/min.***
- Noninvasive.
- No patient preparation
- Allowing detection of both arterial and venous bleeding sites,
- Offers the capability of imaging over a prolonged period, making it useful for detecting intermittent bleeding.

Disadvantages:

- First, the ability to localize the source of bleeding with radionuclide scanning, especially in the foregut, has been repeatedly demonstrated to be poor; even a positive scan does not allow determination of the cause of the bleeding.
- In addition, because nuclear scanning is not therapeutic, a follow-up study, such as catheter-directed angiography or endoscopic examination, must be subsequently performed.



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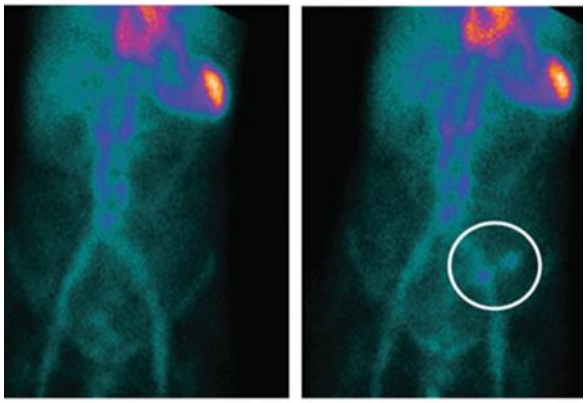


d.

C- Catheter Angiography

- usually performed from a CFA access with the Seldinger technique.
- Upper extremity arterial access can be used when femoral access is not possible; upper extremity access may even be necessary, as it often provides better angles for catheterization of mesenteric vessels relative to the abdominal aorta.
- A 4-F or 5-F cobra or Simmons catheter is typically chosen for selection of SMA, and diagnostic angiography is performed with 30–35 mL of nonionic contrast material injected at a rate of 5–6 mL/sec.
- A 5-F Simmons II catheter is typically chosen for selection of IMA, and diagnostic angiography is performed with 15–20 mL of nonionic contrast material injected at 2–3 mL/sec.

- ***for upper GI bleeding*** => selective catheterization includes the celiac and superior mesenteric arteries.
- ***for lower GI bleeding*** => selective catheterization includes the superior and inferior mesenteric arteries.

Identification of Bleeding Cause:

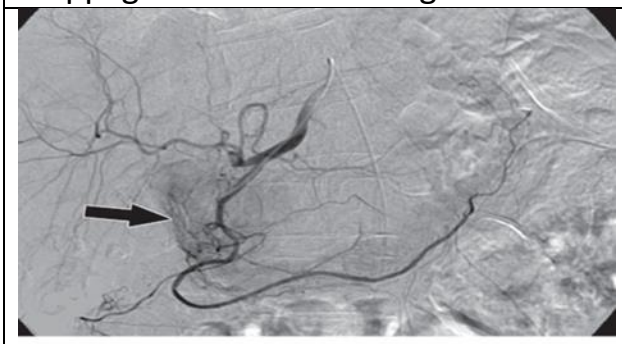
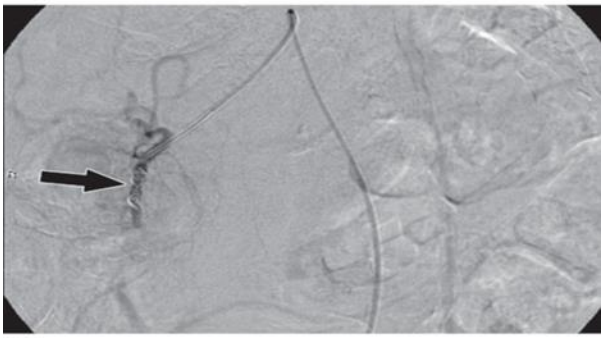
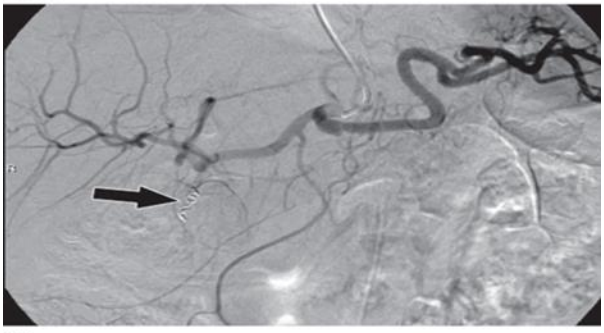
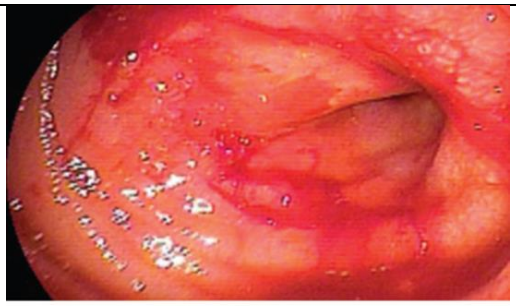
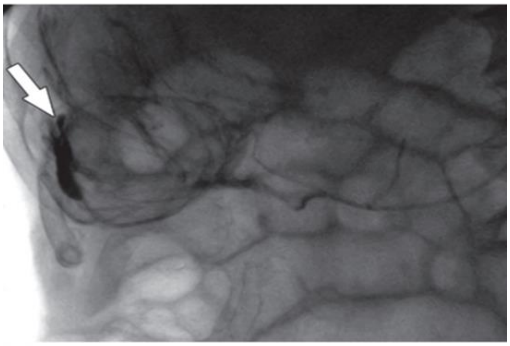
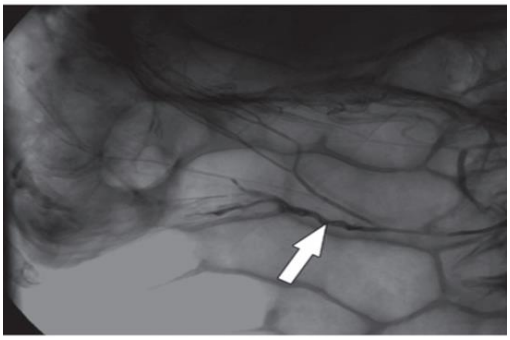
- Contrast material extravasation into the bowel lumen is the definitive angiographic sign of active GI hemorrhage
- but for extravasation to be visualized, bleeding must be active at a minimum rate of 0.5 mL/min
- Indirect signs of bleeding include
    - Contrast material filling of spaces outside the bowel lumen (diverticula)
    - Vascular tufts and early draining veins (angiodysplasia)
    - Hyperemia (colitis)
    - Neovascularity (tumor)
    - Pseudoaneurysm
    - Arteriovenous fistula
- Embolization of the bleeding vessel is the mainstay of transcatheter treatment of nonvariceal GI bleeding, and high technical and clinical success rates have been reported

Advantages:

- The ability to localize the bleeding site and perform therapeutic interventions upon detection.

Disadvantages:

- Invasive nature of the procedure;
- Associated risks related to vascular access and other catheter-related complications (the most feared by far has been bowel ischemia).
- The risk of contrast material reactions.
- The impossibility of achieving prolonged imaging times, preventing the detection of intermittent bleeding

Selective angiogram of the gastroduodenal artery shows contrast material extravasation into the duodenal lumen. Coil embolization (arrow), show stoppage of the GI bleeding	Selective angiogram of the ileocolic artery shows contrast material extravasation into the colonic lumen. Coil embolization (arrow) shows stoppage of the GI bleeding.
 12a.  12b.  12c.	 13a.  13b.  13c.

Small Bowell Obstruction

Role of Imaging => ⑤

- ***Confirm diagnosis*** of bowel obstruction***?***
- ***Severity*** of obstruction***?***
- ***Site*** of obstruction***?***
- ***Cause*** of obstruction***?***
- ***Complications*** of obstruction***?***

❖ Plain Abdominal Radiography:

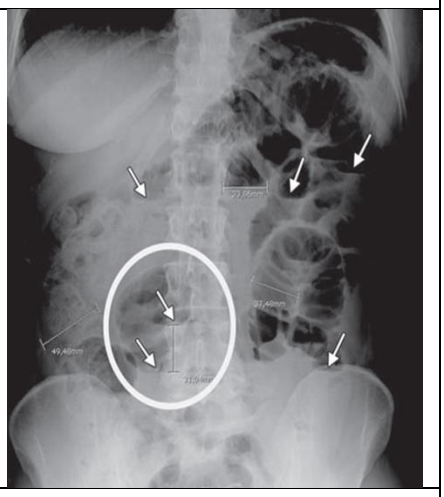
- The initial examination in these patients due to its wide availability and relatively low cost.
  - Diagnostic in 50%–60% of cases;
  - Equivocal in 20%–30%;
  - Normal, nonspecific, or misleading in 10%–20%

✓ **Multiple air-fluid levels >2 (arrows).**

✓ **Distention of the small bowel diameter >2.5 cm.**

✓ **Differential vertical height >2 cm between corresponding air-fluid levels in the same bowel loop (circled area).**

✓ **A small bowel–colon diameter ratio >0.5.**



❖ US:

- Sonography is not commonly used for the evaluation of SBO mainly because:
- Most of the time the bowel loops are filled with gas, producing nondiagnostic sonograms.
- Adhesions (the most common cause of mechanical IO) are not detected with this technique.

❖ CT

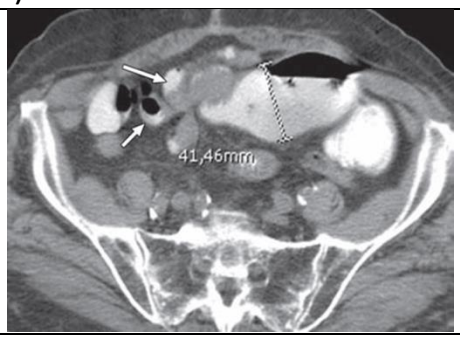
CT is the modality of choice for evaluation of IO:

- **Sensitivity of 90%–96%**
- **Specificity of 96%**
- **Accuracy of 95%.**

1) Diagnosis of SBO ?

- Dilated proximal small bowel loops
- Diameter >3 cm from outer wall to outer wall (dotted line)
- Collapsed distal small bowel loops (arrows).

Role of 3,6,9	Maximum Normal Diameter
SMALL BOWEL	3 cm
LARGE BOWEL	6 cm
CAECUM	9 cm



2) Severity of IO ?

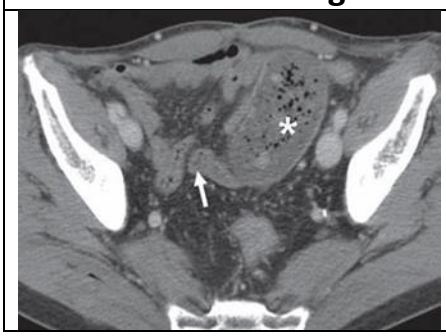
❖ Complete Vs Partial SBO:

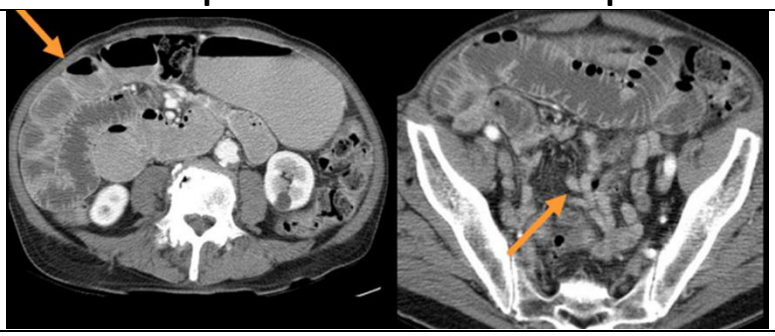
- **<u>Complete SBO</u>** = No passage of contrast medium beyond the point of obstruction on delayed scans obtained at 3–24 hours.
- **<u>Partial SBO</u>** = sufficient flow of contrast material through the transition point of obstruction into the collapsed distal bowel.

❖ High Grade Vs Low Grade SBO

High grade SBO:

Small bowel feces sign	Proximal loops dilated > 50% distal loops





3) Where Is the Transition Point?

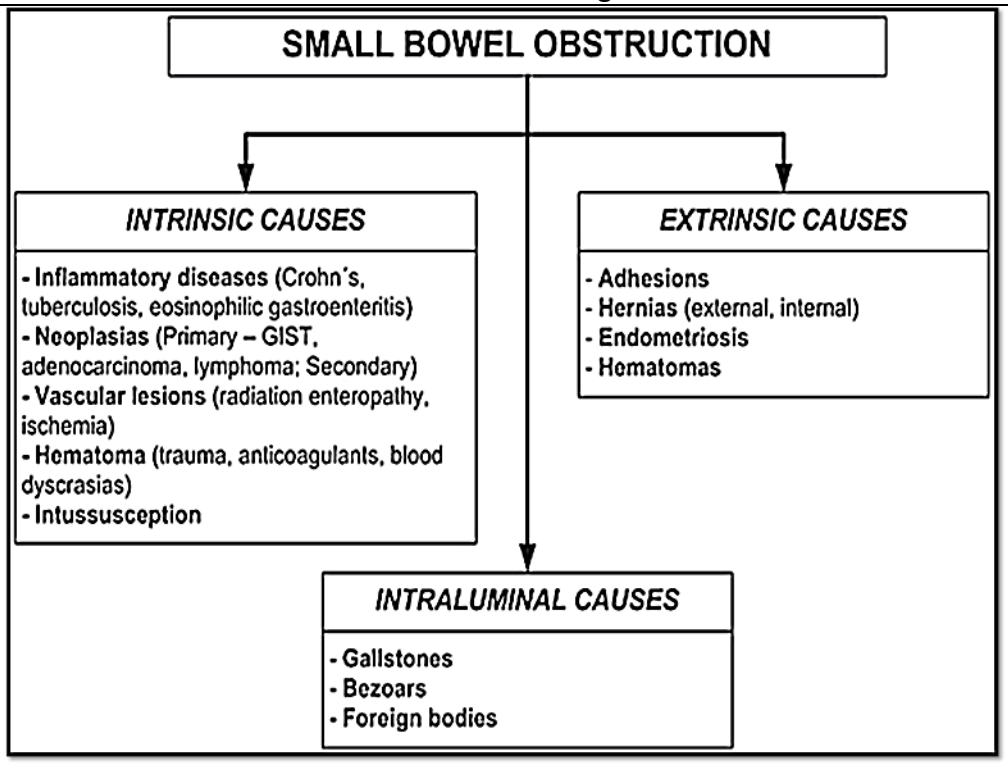
- The transition point is determined by identifying a caliber change between the dilated proximal and collapsed distal small bowel loops

Several methods can be used to improve detection of the transition point

- By acquiring thin section CT data with near-isotropic voxels, MPR and 3D capabilities as currently available with multidetector CT scanners.
- Another technique is based on the method of reading the examination results. Scrolling through CT data in a cine mode at a workstation is advised to rapidly and efficiently identify the transition point:
- This approach should begin in a retrograde fashion by starting at the rectum and proceeding proximally toward the cecum, ileum, and jejunum.
- If the transition point is located proximally (jejunum or duodenum), the position should be confirmed by using an antegrade approach, starting at the stomach

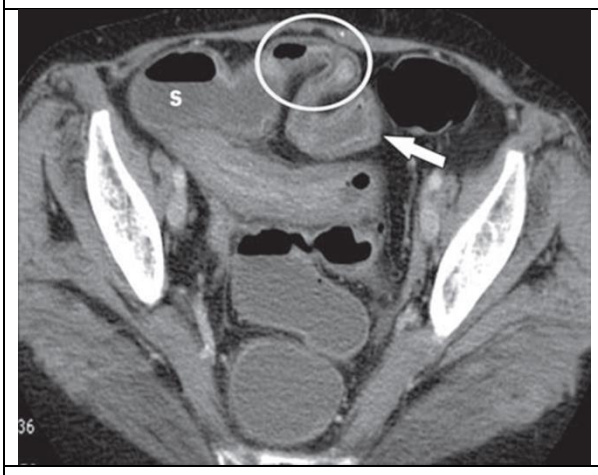
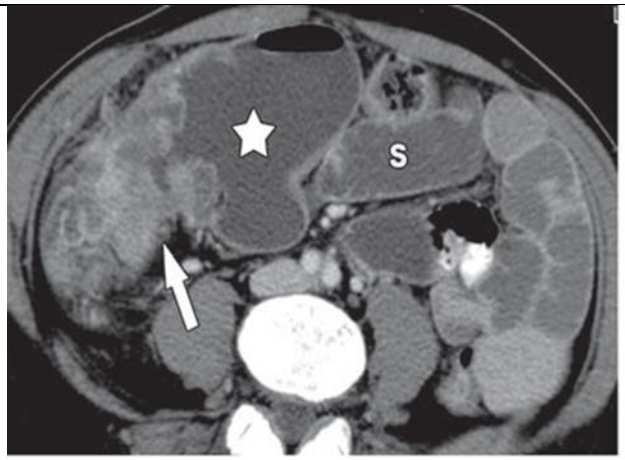
4) Cause of SBO => Look for Transition point?

- A rule of thumb never to forget is that the answer is almost always in the transition point.
- Most intrinsic bowel lesions are seen at the transition point and manifest as localized mural thickening.
- Most extrinsic causes are seen adjacent to the transition point and usually have associated extraintestinal manifestations.
- Most intraluminal causes manifest as endoluminal “foreign objects” with imaging characteristics different from those of the remaining enteric content.

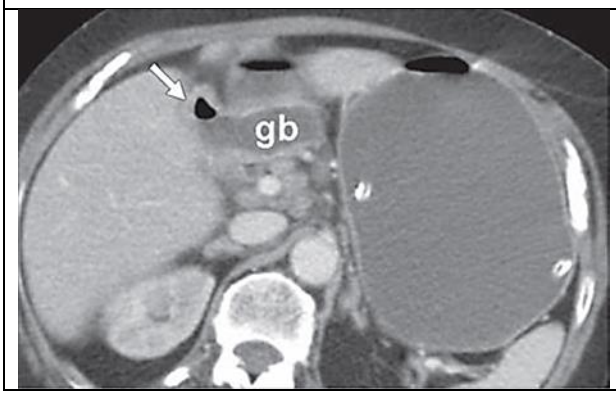
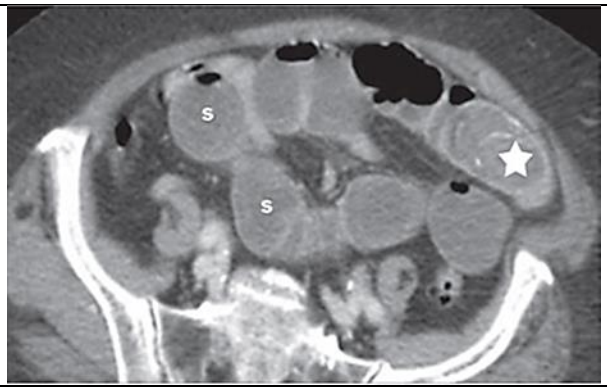


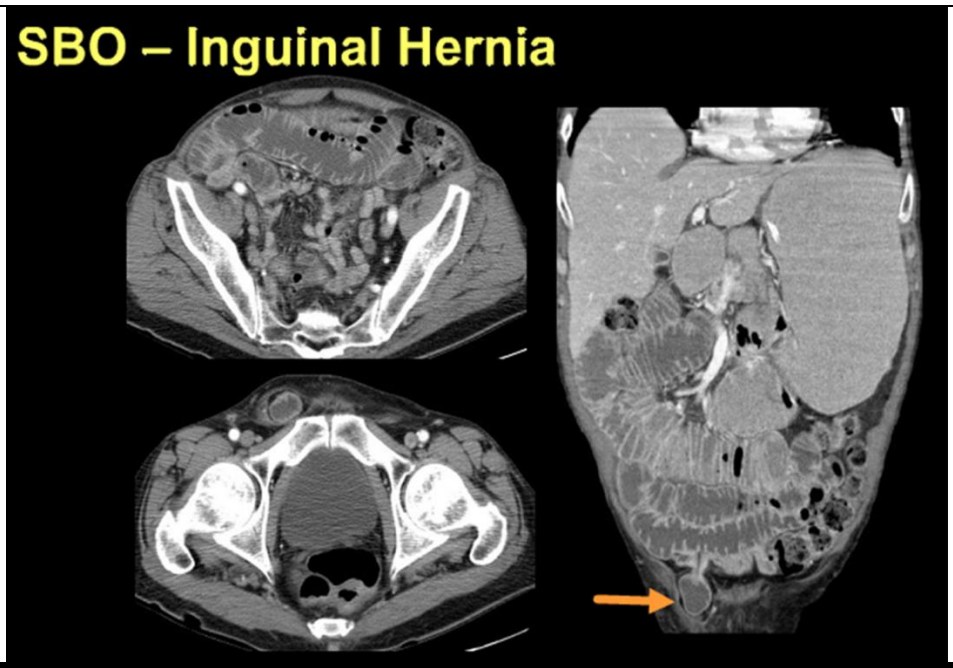
Top causes of SBO:

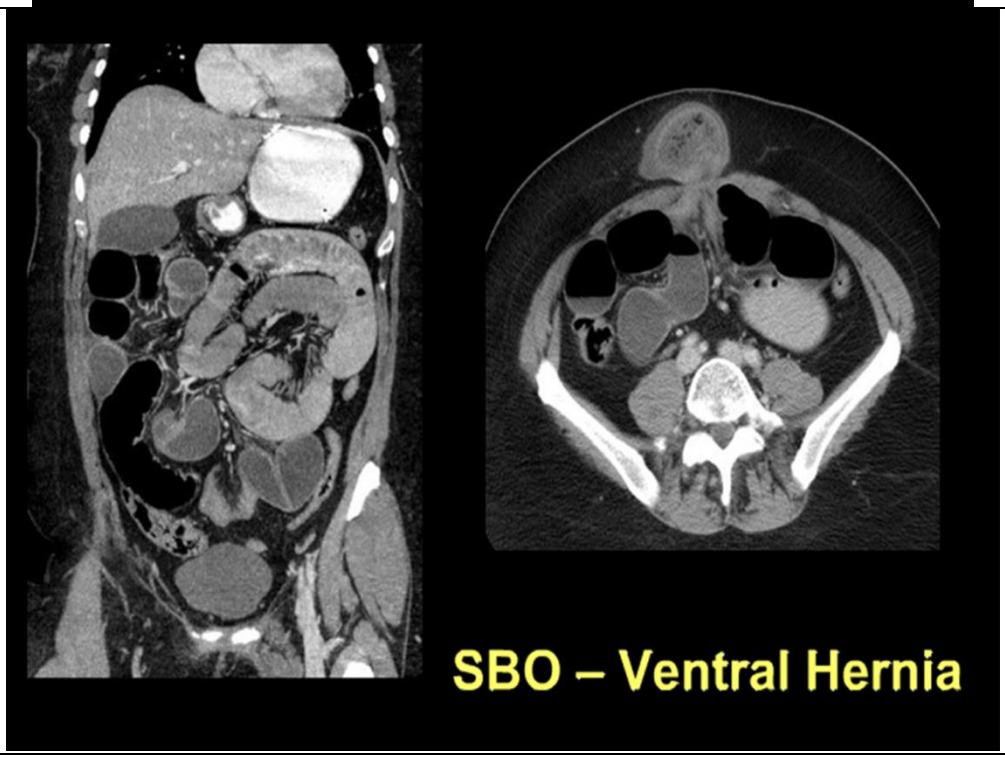
- **Adhesions**
- **Crohn disease**
- **Malignancy**
- **Hernia**

SBO secondary to the acute presentation of Crohn disease	SBO secondary to adenocarcinoma of the cecum with ileocecal valve involvement
	

❖ Gall Stone Ileus

• Pneumobilia	• Gall stone impacted in the bowel • Proximal bowel dilatation
	


SBO – Inguinal Hernia

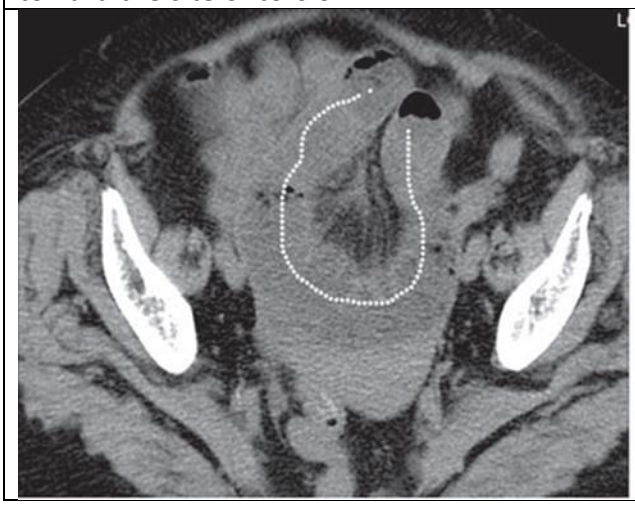
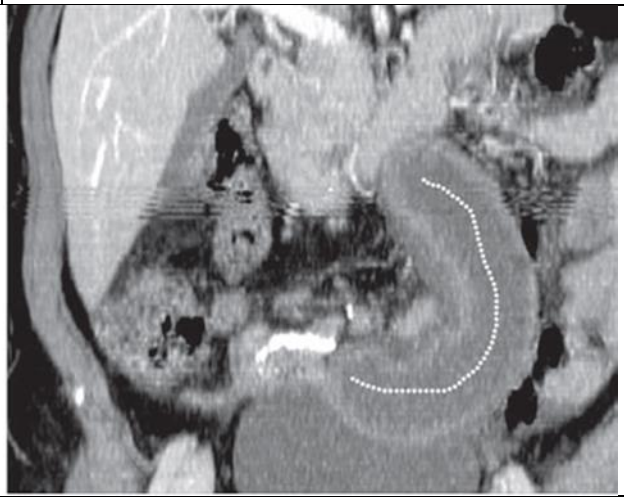

SBO – Ventral Hernia

5) Is the SBO Simple or Complicated?

- **Simple obstruction** of the bowel is considered when the bowel is occluded at one or several points along its course.
- **Closed-loop obstruction** is diagnosed when a bowel loop of variable length is occluded at two adjacent points along its course.
- **Strangulation** is defined as a closed-loop obstruction associated with intestinal ischemia.

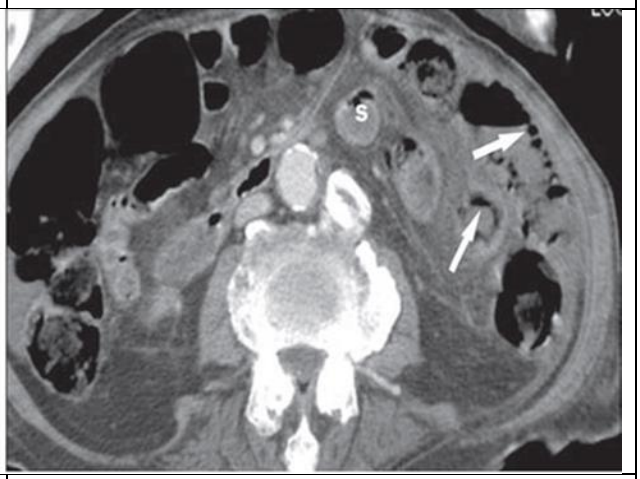
❖ CT findings of Closed-loop obstruction:

- Fixed radial distribution of several dilated, usually fluid-filled bowel loops = U-shaped or C-shaped configuration
- Stretched and prominent mesenteric vessels converging toward the point of torsion.
- A narrow pedicle can be formed, leading to torsion of the loops and producing a small bowel volvulus.
- A "beak sign" is seen at the site of the torsion as a fusiform tapering,
- A "whirl sign" can be seen, reflecting rotation of the bowel loops around the fixed point of obstruction

Radial distribution of small bowel loops with a U-shaped configuration Stretched mesenteric vessels converging toward the site of torsion	Radial distribution of small bowel loops with C shaped configuration
	

❖ CT Findings of Strangulation:

- Diffuse circumferential wall thickening
- Increased attenuation of the affected bowel wall = Halo or "Target sign"
- Lack of wall enhancement; asymmetric enhancement or even delayed enhancement may also be found.
- Gas in the non-dependent bowel wall = Pneumatosis intestinalis
- Gas in the portal vein
- Fluid and hemorrhage in the mesentery in-between bowel loops

Gas in the intrahepatic portal veins	Pneumatosis intestinalis
	
Wall thickening + Target Sign	**Hypoenhancement of mucosa**

Abdominal Hernia

- Hernia is protrusion of organ or soft tissue through an abnormal opening

Risk factors:

- Obesity
- Chronic cough
- Lifting heavy objects
- Straining
- Constipation
- Pregnancy
- Ascites

Role of CT => ⑤ Questions:

- Diagnosis of hernia & Differentiation of hernias from other abdominal masses (tumors, hematomas, abscesses)
- Anatomic detail of the abdominal defect.
- Identification of hernia content.
- Detection of hernia complications.
- Detection of postoperative complications.

Types of hernia:

- **Internal hernia**
- **External hernia**
- **Diaphragmatic hernia**

I- Internal Hernia

- An internal hernia is defined as the herniation of a viscus through a defect, pouch, or opening in the abdominal cavity.
  - **Acquired defects** of the mesentery or omentum resulting from surgery or trauma are common causes of internal hernia in adults
  - **Congenital anomalies** of intestinal rotation and peritoneal fixation such as paraduodenal hernia, paracecal hernia, intersigmoid hernia, and transmesenteric hernia may be present.
  - **Rarely, a normal opening** such as the foramen of Winslow may lead to internal hernia

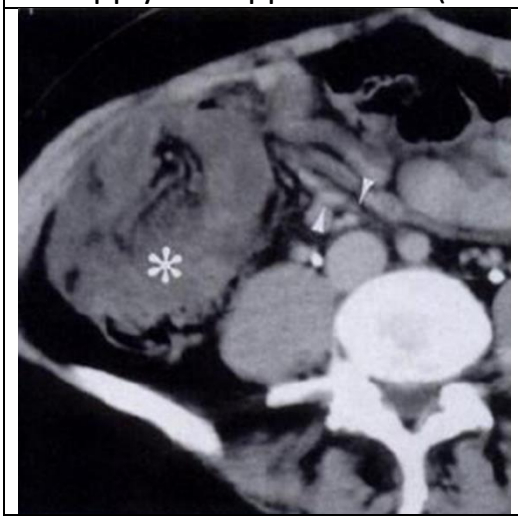
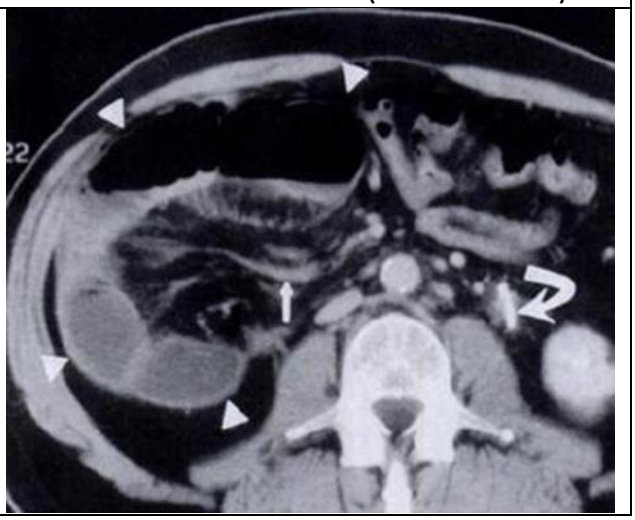
1) Paraduodenal Hernia

- Paraduodenal hernias are congenital and are caused by small-bowel entrapment under the right or left mesocolon.

2 Types:

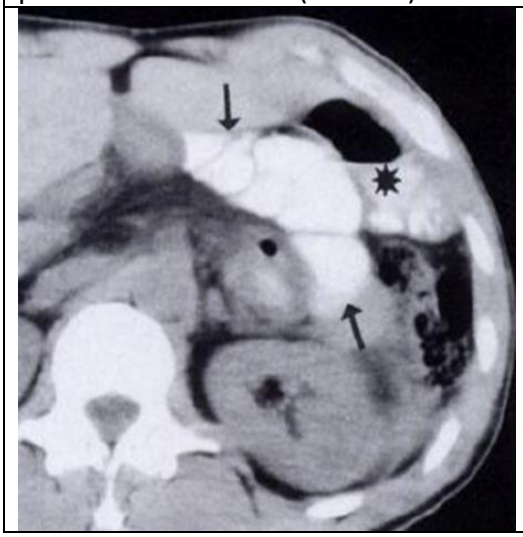
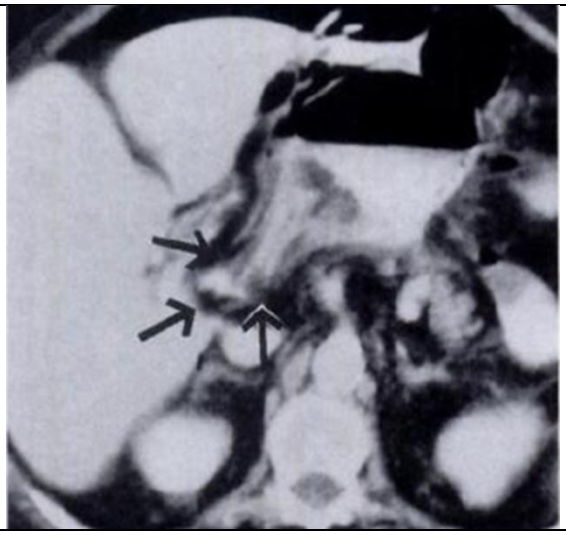
- Left paraduodenal hernia through the Landzert fossa
- Right paraduodenal hernia through the Waldeyer fossa.

Right Paraduodenal Hernia.

CT scan shows superior mesenteric artery deviating to right (arrowheads) to supply entrapped bowel (asterisk).	CT scan shows branch of superior mesenteric artery (straight arrow) contained in hernia sac (arrowheads).
	

2) Herniation Through the Foramen of Winslow

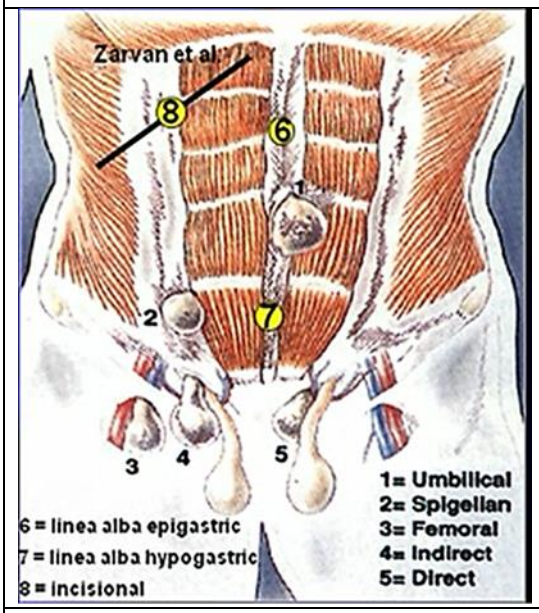
- Herniation through the foramen of Winslow by small or large intestine

Herniation of small intestine through foramen of winslow. Small bowel (arrows) in lesser sac, directly posterior to stomach (asterisk).	Cecal herniation through foramen of winslow. Ileocecal mesentery passing through foramen of winslow (arrows).
	

3) Transmesenteric hernia

- is a broad category of bowel herniation through defects in any of the three true mesenteries (small bowel mesentery, transverse mesocolon, and sigmoid mesentery).
- The most common type of transmesenteric hernia is the transmesocolic hernia, due to a defect in the transverse mesocolon (mesentery of the transverse colon).
- Transmesocolic hernia is seen most commonly post Roux-en-Y gastric bypass or biliary-enteric anastomosis from liver transplant.
- The lack of confining hernia sac and variable imaging appearance make diagnosis difficult.
- A clue on imaging may be posterior displacement of the colon, with small bowel located anterior to the colon.
- The SMA and SMV may be displaced and engorged.
- Internal hernias carry a high rate of volvulus.
- If volvulus is present, the whirl sign may be visible.
- Transmesenteric hernias are also the most common type of hernia in children, not due to surgery but secondary to a congenital mesenteric defect thought to be from prenatal intestinal ischemia. In children, the mesenteric defect has a variable position.

II- External Hernia



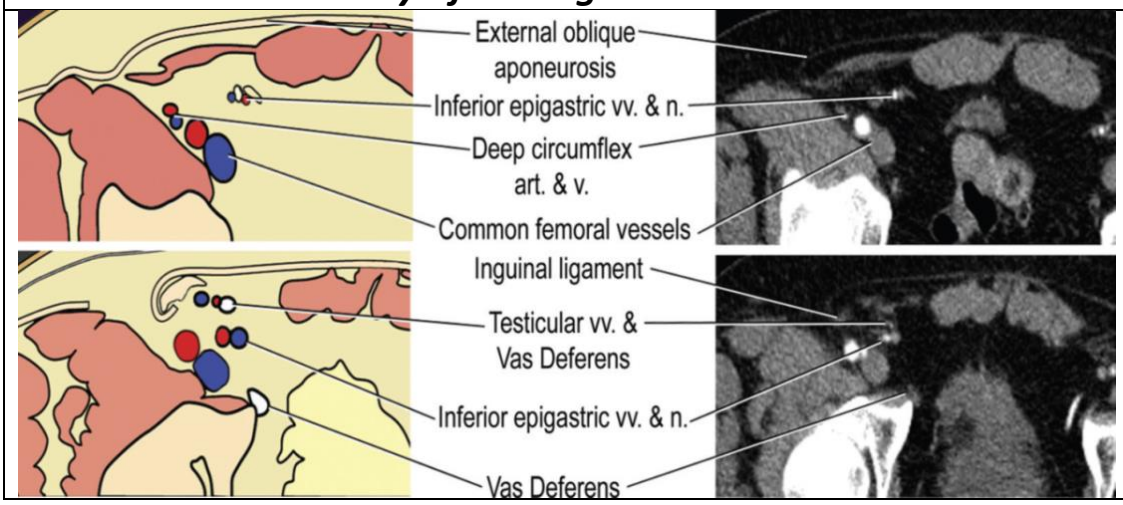
- **Groin Hernia:**
  - **Inguinal hernia**
  - **Femoral hernia**
  - **Obturator hernia**
- **Ventral Abdominal wall hernia:**
  - **Umbilical hernia**
  - **Paraumbilical hernia**
  - **Epigastric hernia**
  - **Hypogastric hernia**
  - **Spigelian hernia**
- **Lumbar hernia:**
  - **Grynfeltt-Lesshaft hernia**
  - **Petit hernia**
  - **Diffuse lumbar hernias**
- **Incisional hernia**

A- Groin Hernias

1) Inguinal Hernia

- Inguinal hernias are the most common type of abdominal wall hernia.
- In children (most commonly indirect type hernias) or adults (both direct and indirect types)
- M>F
- In boys, most inguinal hernias develop because the peritoneal extension accompanying the testis fails to obliterate.
- In adults, inguinal hernias are caused by acquired weakness and dilatation of the internal inguinal ring

❖ ***Normal Anatomy of the Inguinal Canal***

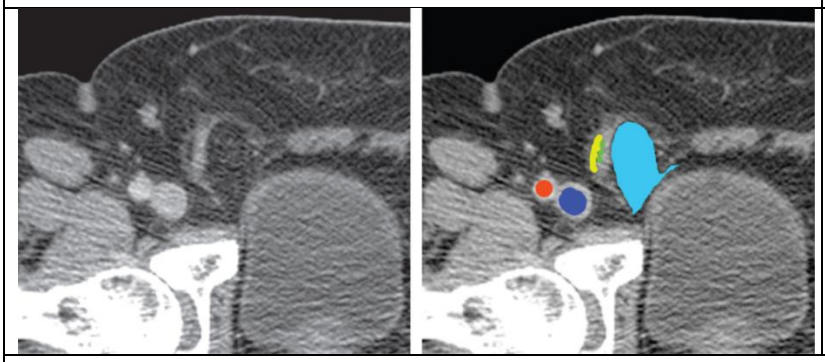


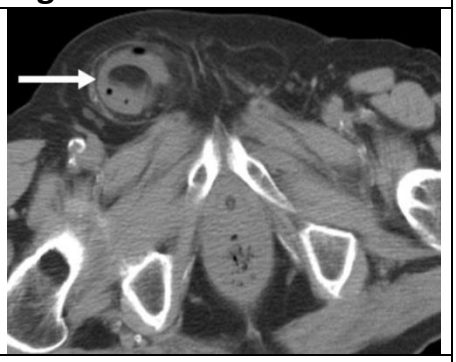
❖ *2 types:*

i- Direct Inguinal hernia:

- Direct inguinal hernias protrude anteromedial and inferior to the course of the inferior epigastric vessels.
- The inguinal canal contents (ie, fat, testicular vessels, vas deferens, etc) are compressed and stretched laterally by the hernia
- The normal fat of the inguinal canal is pushed into a semicircle of tissue that resembles a moon crescent. This lateral crescent of fat is a useful diagnostic sign of direct inguinal hernia

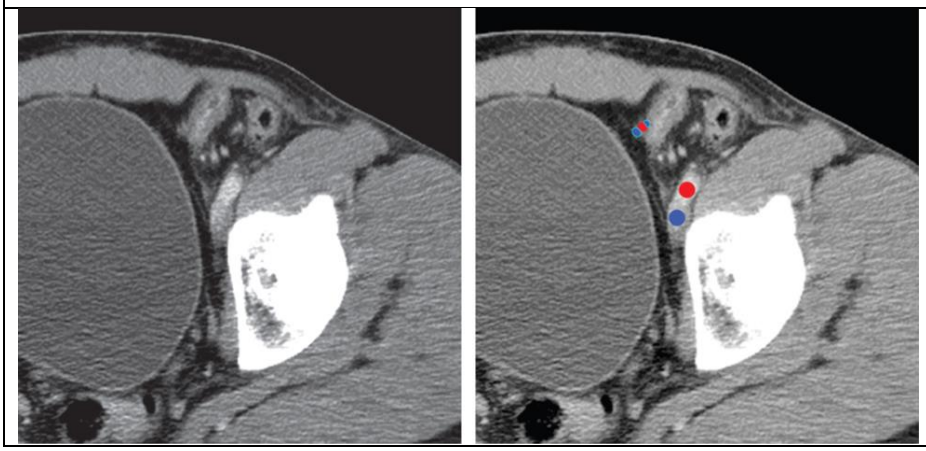
Fat-containing direct inguinal hernia	**Bowel containing Direct inguinal hernia**





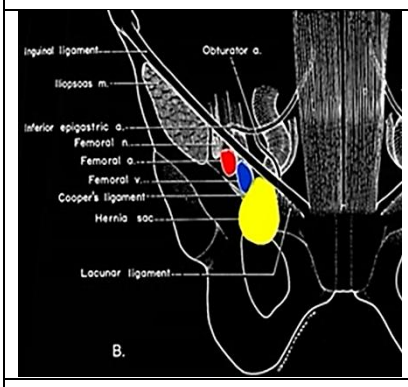
ii- InDirect Inguinal hernia:

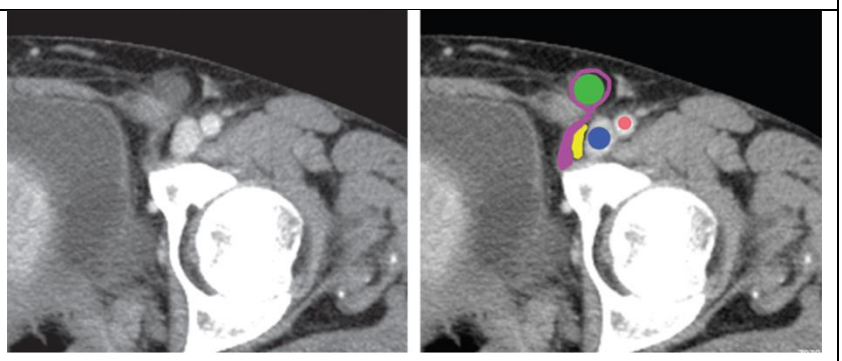
- Indirect inguinal hernias protrude posterolateral and superior to the course of the inferior epigastric vessels.
- As the hernia sac protrudes further caudally, it is directed lateral to medial within the inguinal canal.
- The inguinal canal contents are not compressed into a lateral crescent and may be difficult to identify, as the canal contents will appear to make up part of the hernia and may appear to be contained within the hernia sac.



2) Femoral Hernia:

- Femoral hernias are less common than inguinal hernias.
- They occur medial to the femoral vein and posterior to the inguinal ligament, usually on the right side.
- F>M.



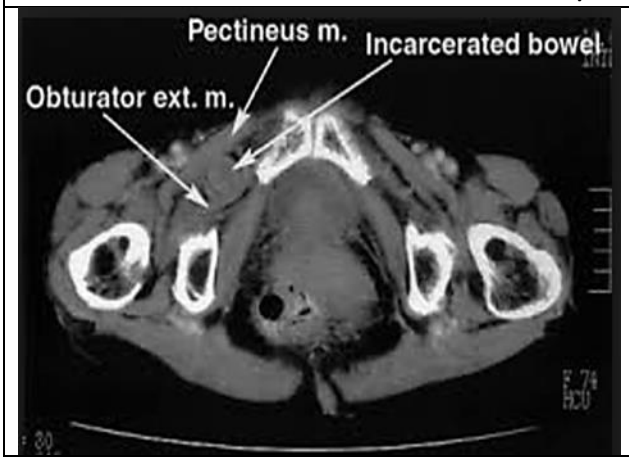


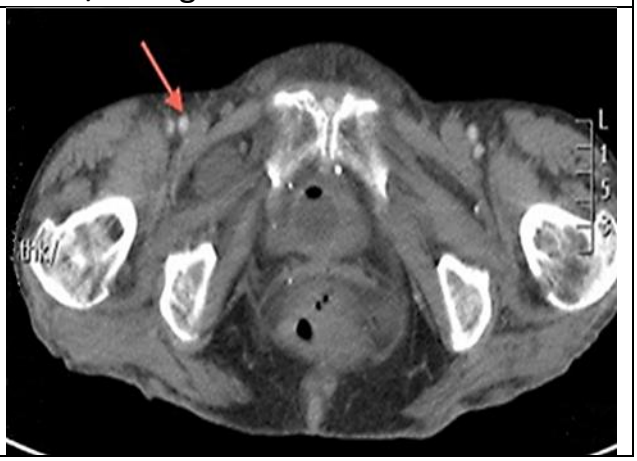
3) Obturator hernia

- Characterized by bowel herniating between the obturator externus and the pectineus muscles.
- Rare type of abdominal hernia
- can be very difficult to diagnose clinically.

Clinical presentation:

- Asymptomatic
- Compress the obturator nerve: Howship-Romberg sign: Patients present with pain and paraesthesia along the inner aspect of the thigh, down to the knee.
- Contain bowel which incarcerates/obstructs/strangulates





B-Ventral Abdominal Wall Hernias

- Ventral hernias include all hernias in the anterior and lateral abdominal wall.

Midline	**Paramidline**
• Umbilical hernia • Paraumbilical hernia • Epigastric hernia above umbilicus. • Hypogastric hernia below umbilicus.	• Spigelian hernia

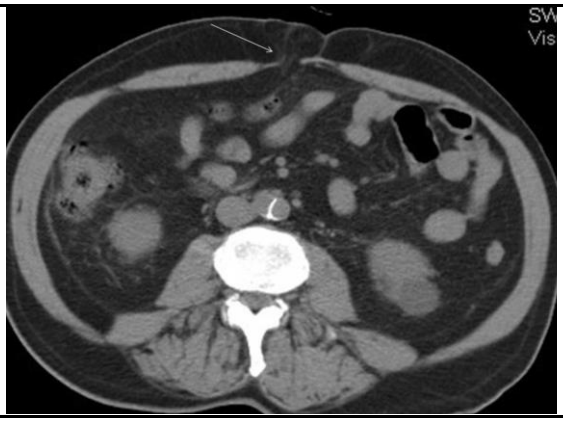
1) Umbilical hernia

- is the most common ventral hernia and occur in the midline
- risk factors: obesity, multiparity, ascites, large intra-abdominal mass
- Umbilical hernias commonly contain fat, mesentery or small and/or large bowel.

- **Congenital:** physiological herniation through the umbilicus occurs during the 10th week of gestation and congenital umbilical hernias occur when there is incomplete closure of the anterior abdominal wall after the gut returns to the abdominal cavity
- **Acquired:** more common in adults

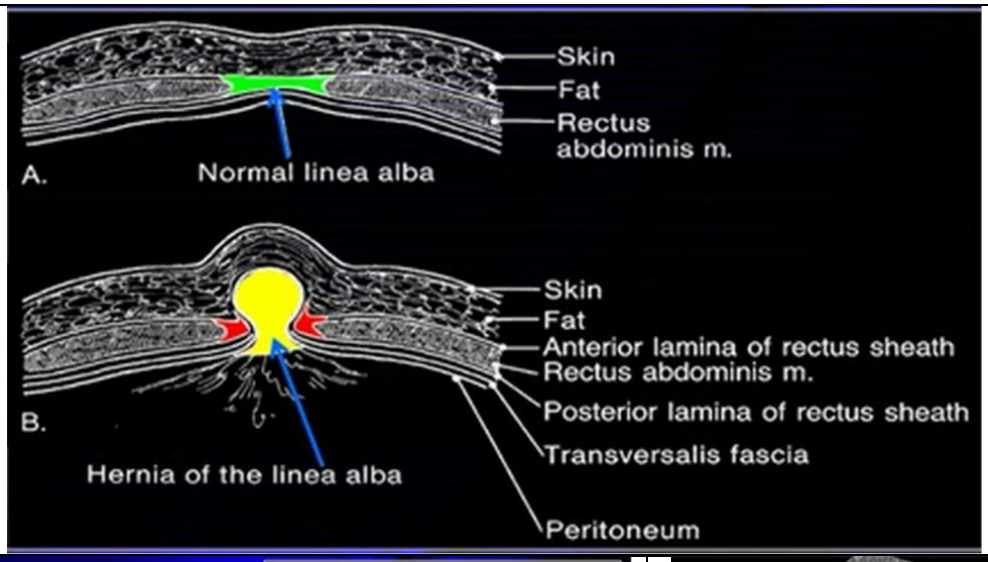
2) Paraumbilical hernias

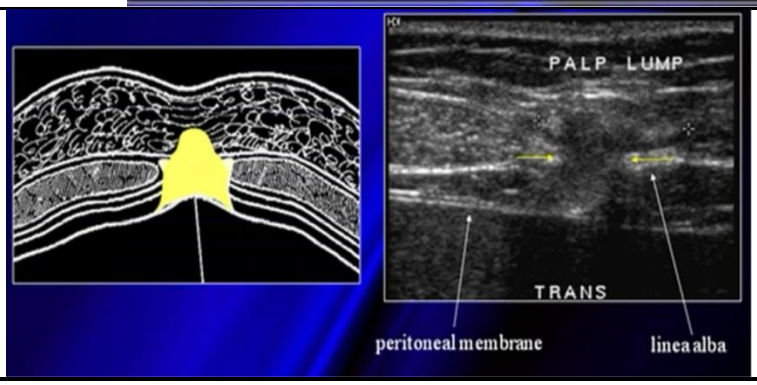
- are a type of midline ventral abdominal hernia.
- Paraumbilica hernias occur near the umbilicus and abdominal contents protrude through a defect in the linea alba and can be quite large.
- They are usually related to rectus abdominis muscle diastasis.

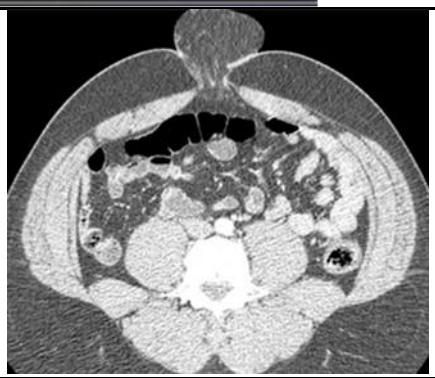


3) Epigastric hernia = Fatty hernia of linea alba

- Ventral abdominal wall hernia through a defect in linea alba superior the umbilicus.





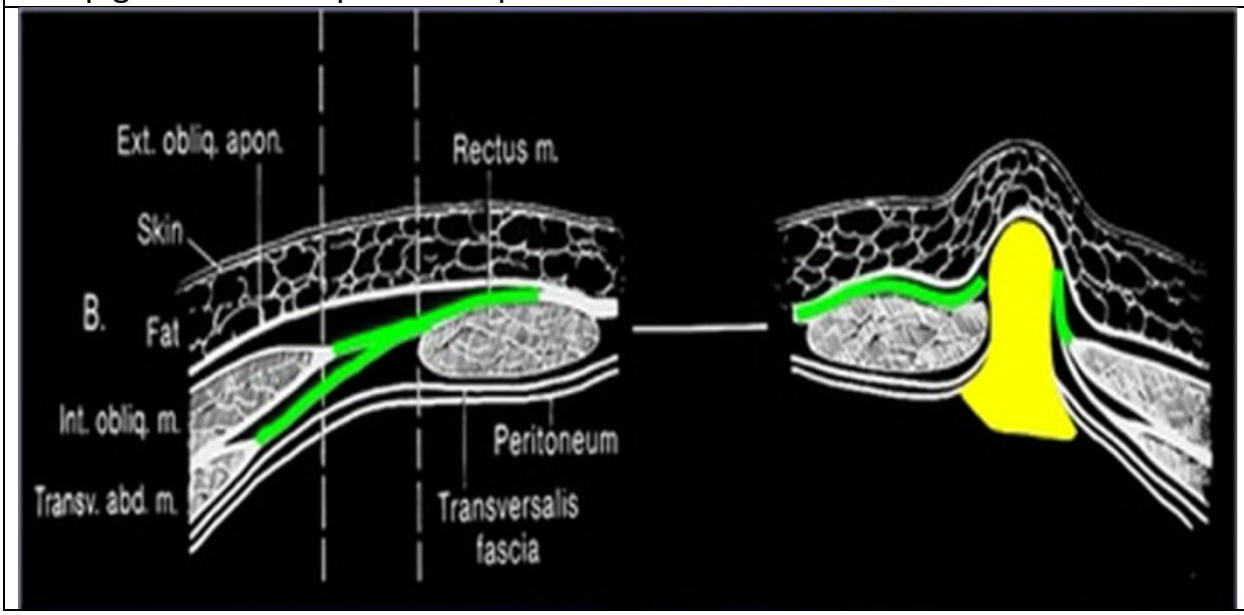


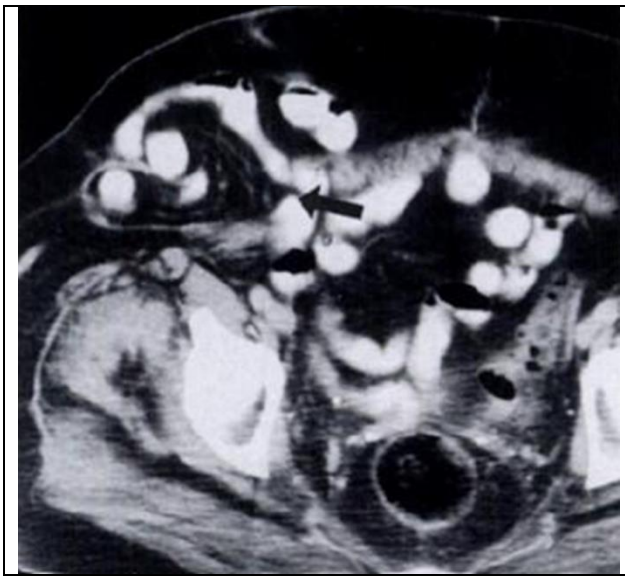
4) Hypogastric hernia

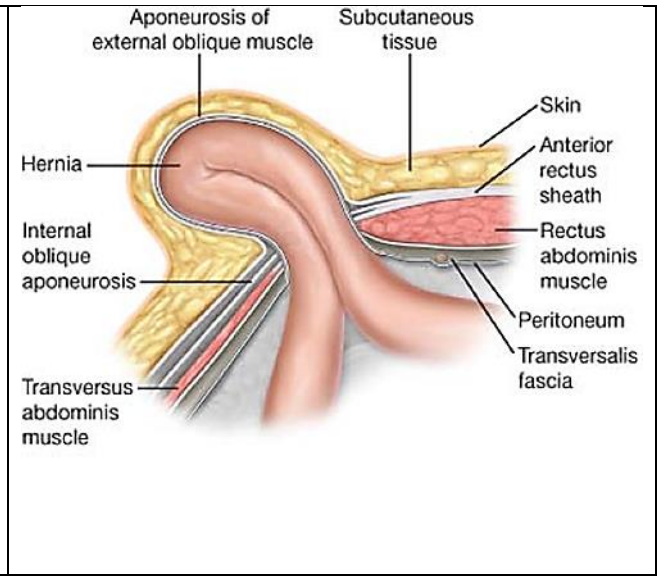
- Ventral abdominal wall hernia through a defect in linea alba inferior the umbilicus.

5) Spigelian hernia

- Spigelian hernia is an acquired ventral hernia through the linea semilunaris.
- The line where the sheaths of the lateral abdominal muscles fuse to form the lateral rectus sheath.
- They are almost always found just above the point where the inferior epigastric vessels pierce the posterior wall of the rectus sheath.







C- Lumbar hernias

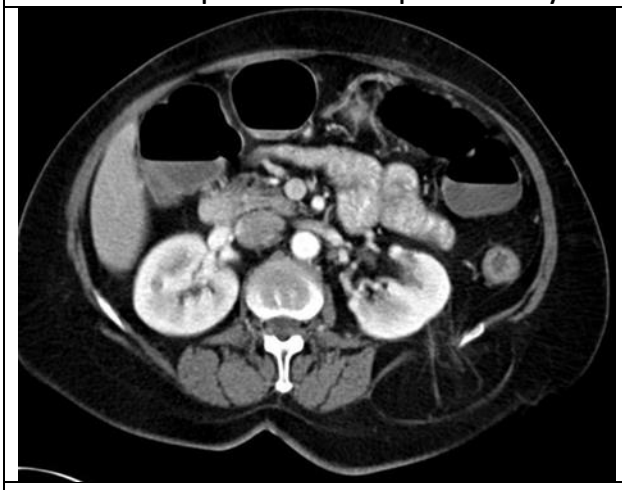
- More frequent after trauma or surgery.
- They are located between the 12th rib and iliac crest, occurring through defects in lumbar muscles or posterior fascia:

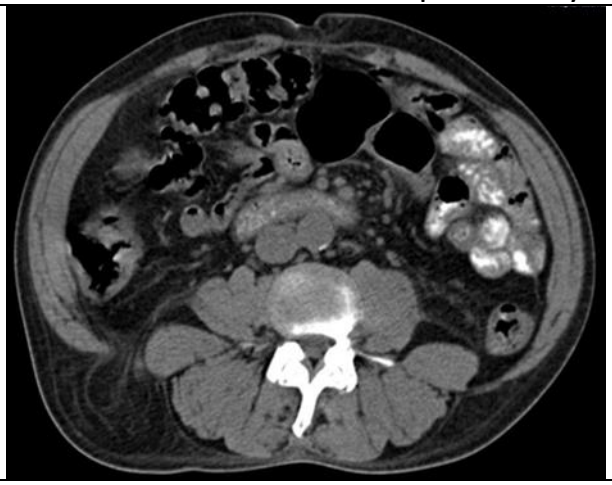
Grynfeltt-Lesshaft hernia:
Through superior lumbar triangle:

- Internal oblique muscle anteriorly
- 12th rib superiorly
- Erector spinal muscle posteriorly.

Petit hernia :
Through inferior lumbar triangle:

- External oblique muscle anteriorly,
- Iliac crest inferiorly,
- Latissimus dorsi muscle posteriorly.





Diffuse lumbar hernias

- may also occur, usually after flank incisions in kidney surgery, and may contain bowel loops, retroperitoneal fat, kidneys, or other viscera

D- Incisional hernias

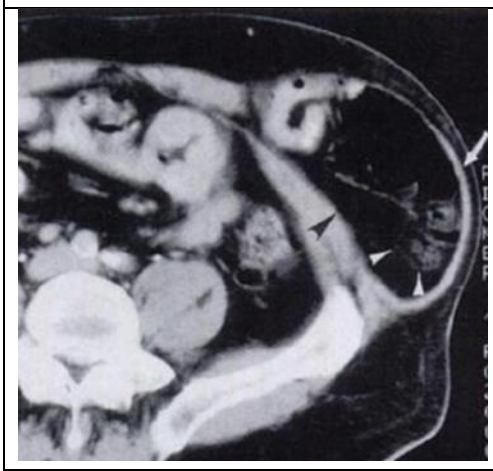
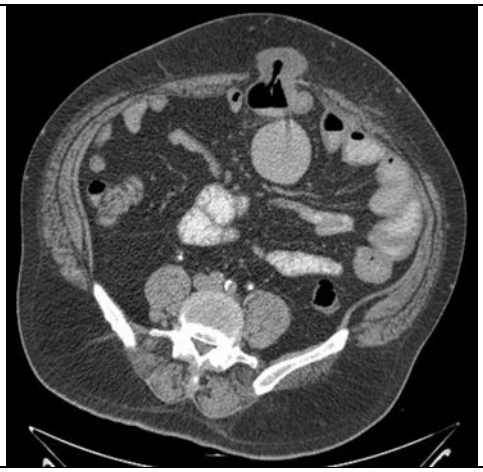
- Complication of abdominal surgery.
- They can occur at any point in the abdominal wall, frequently causing symptoms in the first few months after surgery

<u>Parastomal hernia</u>

- are considered a subtype, adjacent to the stoma and particularly difficult to detect in the physical examination.

E- Less common hernias

- Amyand hernia: is a rare form of inguinal hernia in which the vermiform appendix is located within the hernial sac.
- Littre hernia: is a hernia containing a Meckel's diverticulum.

Interparietal hernia	**Richter hernia**
located between the muscular planes of the abdominal wall, without communication with the subcutaneous tissue	an abdominal hernia where only a portion of the bowel wall is herniated comprise 10% of strangulated hernias
	

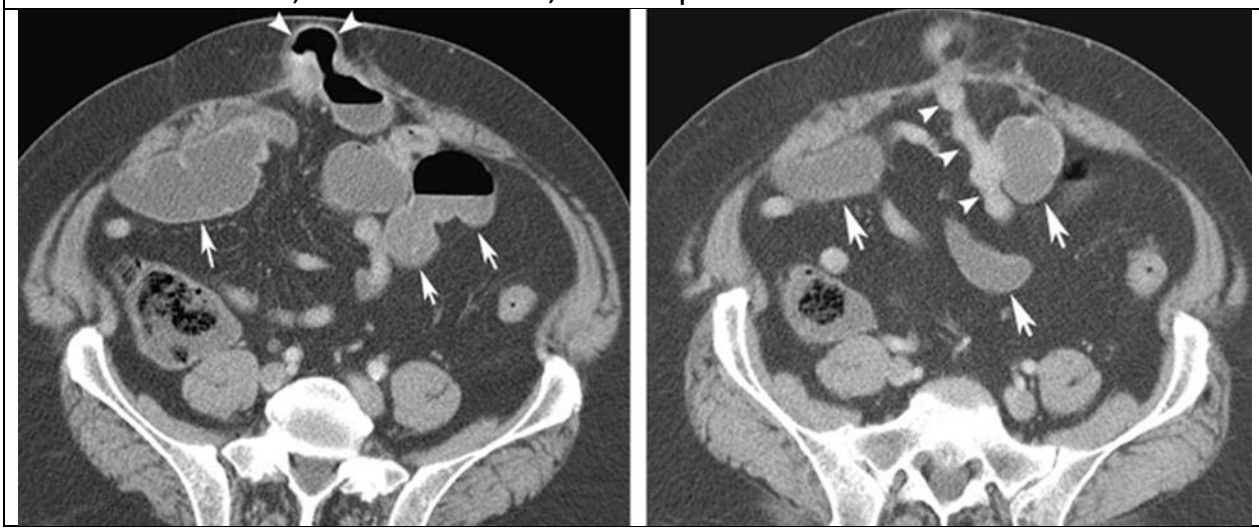
❖ Complications of Abdominal Wall Hernias

1) Bowel Obstruction

- Abdominal wall hernias are 2nd leading cause of small bowel obstruction, after adhesions, (10%–15% of cases).

Imaging findings:

- Dilated bowel proximal to the hernia
- Normal-caliber, reduced-caliber, or collapsed bowel distal to the obstruction.



2) Incarceration

- Incarceration refers to an irreducible hernia and is diagnosed clinically when a hernia cannot be reduced or pushed back manually.
- The diagnosis of incarceration cannot be made with imaging alone but can be suggested when herniation occurs through a small defect and the hernia sac has a narrow neck.
- Detection is important because incarceration predisposes to complications such as Obstruction, inflammation, or ischemia.

3) Strangulation

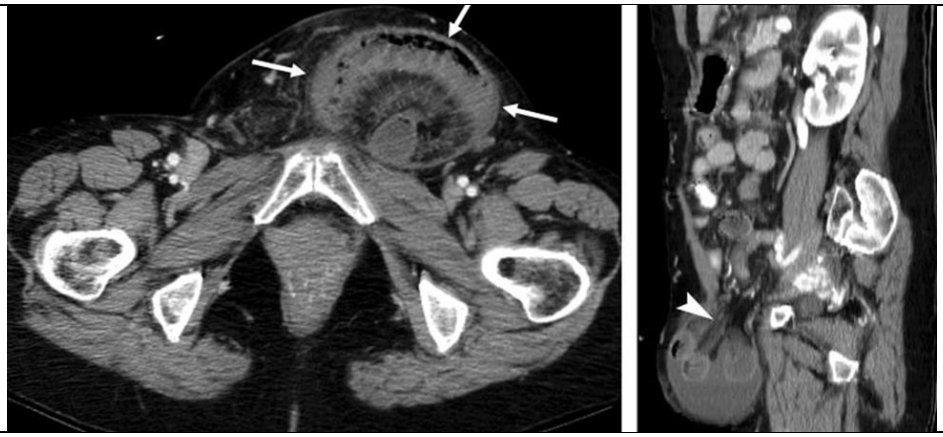
- Strangulation refers to ischemia caused by a compromised blood supply.
- It usually occurs when the hernia defect obstructs the afferent and efferent bowel loops, creating a closed loop within the herniated bowel.

CT Findings in closed loop obstruction include:

- Dilated, fluid-filled U- or C-shaped loops of bowel entrapped within the hernia sac and proximal obstruction.

CT Findings in ischemia include:

- Bowel wall thickening
- Abnormal mural hypo- or hyper-attenuation and enhancement
- Mesenteric vessel engorgement
- Fat obliteration, mesenteric haziness, and ascites.



4) Trauma

Hernias may be complicated by trauma in two ways:

- A hernia may be caused by trauma (traumatic hernia)
- There may be trauma to a preexisting hernia.

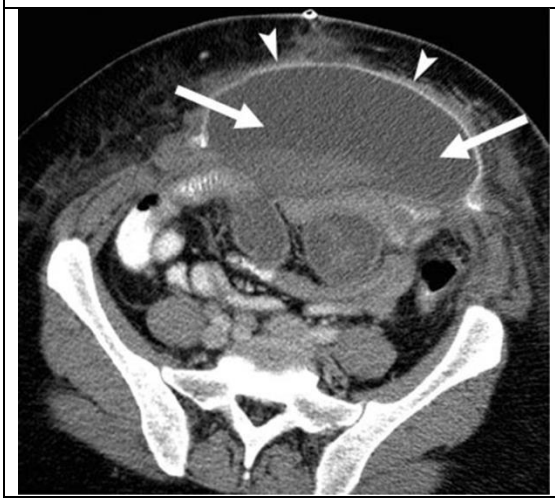
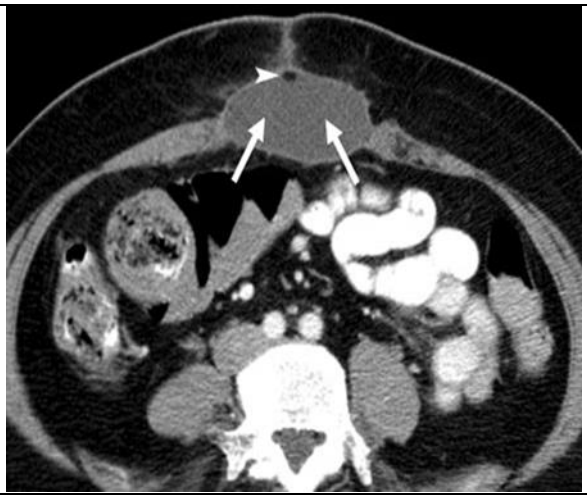
5) Herniation Of Intraabdominal Organs

- Solid (eg, liver, kidneys)
- Nonsolid (eg, stomach, bladder, neobladder)

An incisional (epigastric) hernia containing the left hepatic lobe (arrows).	An incisional (epigastric) hernia containing the gastric antrum (arrows).
Inguinal hernia containing urinary bladder	

❖Postsurgical Complications

1) **Hernia recurrence** constitutes the most common complication after hernia repair, usually occurring 2–3 years after surgery.
2) **Fluid collections** occur frequently in the immediate postoperative period after hernia repair (up to 17% of cases). These collections usually contain serous fluid (seromas) or blood products (hematomas).
3) **Infected postoperative fluid collections** occur in 1%–5% of patients after hernia repair. Infected fluid collections may involve subcutaneous (superficial) or mesh-surrounding (deep) tissues. Findings that are suspicious for infected fluid collections vary and include:
   - Development of gas
   - Thick septa.
   - An enhancing rim,
   - Fat stranding in surrounding tissues.
   - Imaging- guided aspiration is often necessary to establish the diagnosis.
4) **Mesh-related Complications:**
   - Inflammatory reactions may lead to fibrosis of tissues surrounding the mesh. This condition may be suspected if the mesh has an asymmetric or irregular shape at CT.
   - Mesh shrinkage may also occur

Seroma	Infected fluid collection
	

INTUSSUSCEPTION

- Invagination or telescoping of a proximal segment of bowel (intussusceptum) into lumen of a distal segment (intussuscipiens)
- Bowel within bowel, "coiled spring" appearance

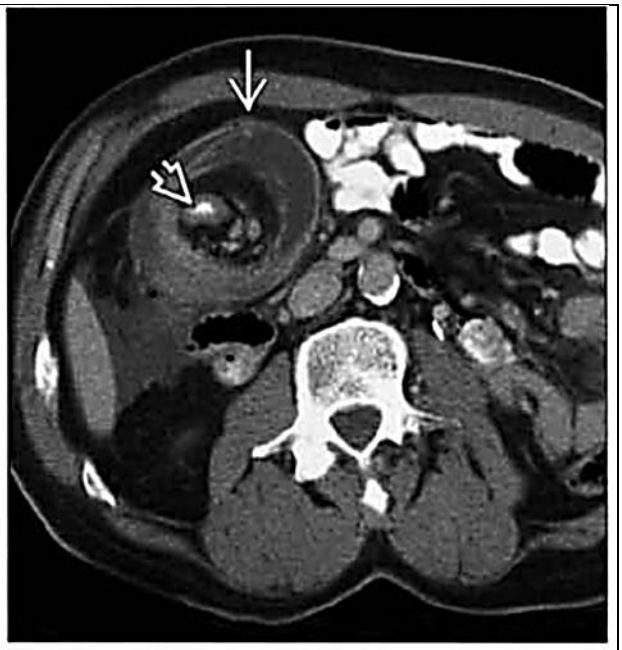
Location:

- **Ileocolic**: most common (75-95%), presumably due to the abundance of lymphoid tissue related to the terminal ileum and the anatomy of the ileocaecal region
- **Ileoileocolic:** second most common
- **Ileoileal and colocolic:** Uncommon

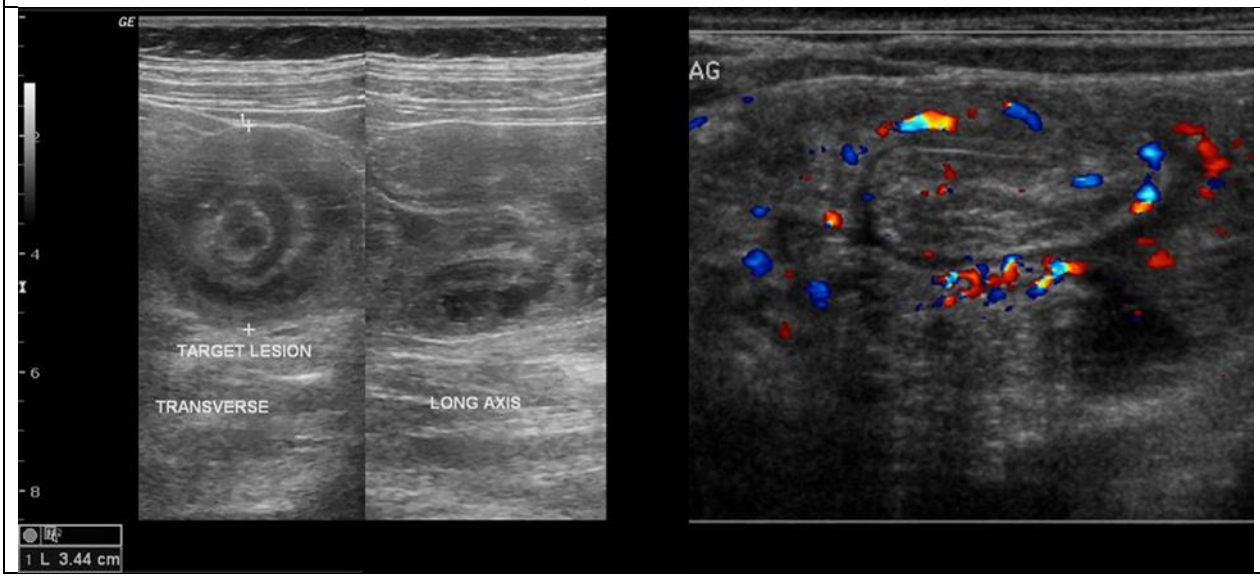
Imaging findings:

- Target" sign:
  - Outer layer represents intussuscipiens
  - Inner layer represents intussusceptum
- Sausage-shaped mass: A layering pattern (later phase)
  - Alternating layers of low-attenuation (mesenteric fat) & high-attenuation areas (bowel wall)
- Fluoroscopic guided barium study
  - Classic "coiled spring" appearance
  - Due to trapping of contrast between folds of intussusceptum & intussuscipiens
- Reniform mass: Due to edema or mural thickening (vascular compromise)
- Vascular compromise: Seen in returning wall of intussusceptum as hypodense layer in middle of inner part of thick bowel wall & crescent-shaped fluid or gas collections
- Features of intestinal obstruction
  - Proximal bowel distension + Air-fluid levels
  - Distal collapsed bowel

Graphic shows ileocolic intussusception with a tumor in the bowel wall as the "lead mass". Note vascular compromise and ischemia.



Axial CECT shows ileocolic intussusception. The outer ring (arrow) is the wall of the intussuscipiens (colon, here) while the intussusceptum is the small intestinal segment (open arrow).



Gastrointestinal Tract Volvulus

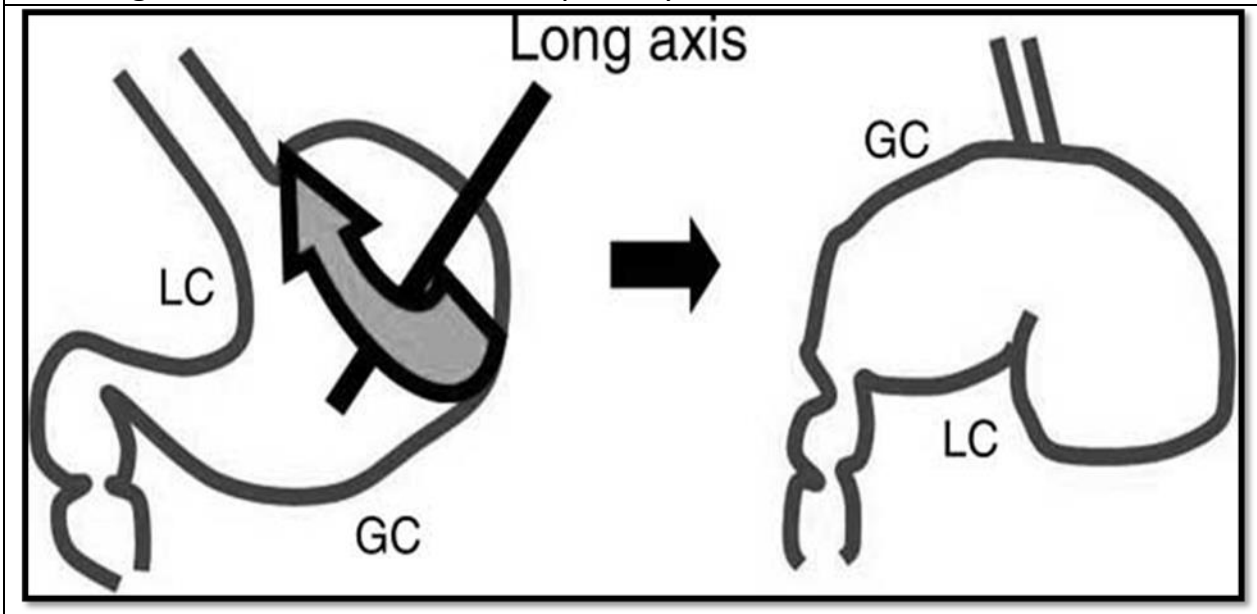
1) Gastric Volvulus

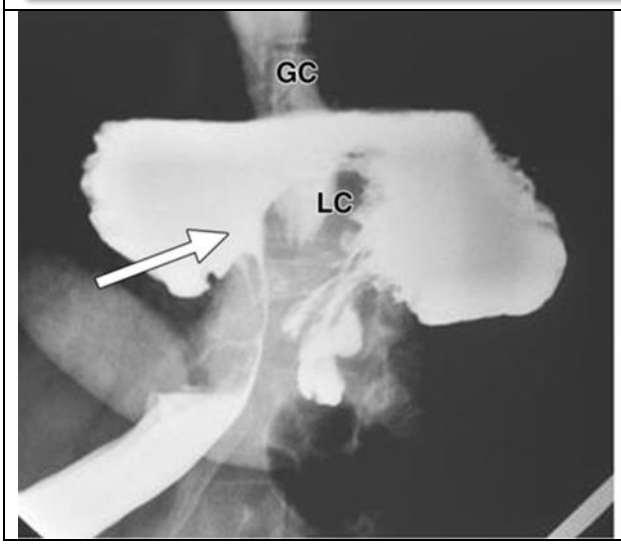
Borchardt Triad consists of:

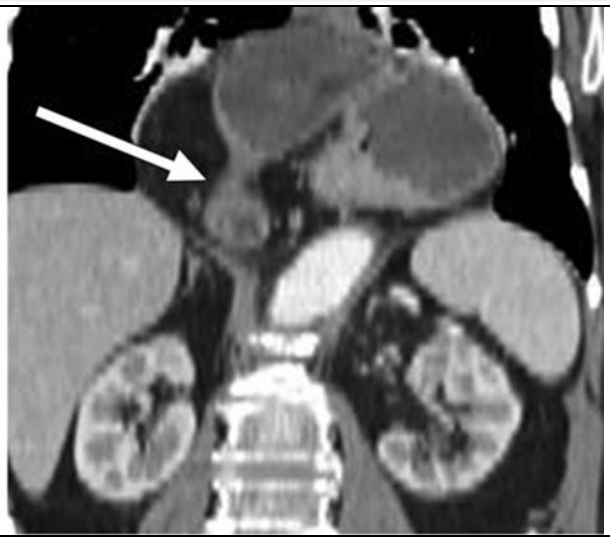
- Sudden epigastric pain
- Intractable retching
- Inability to pass a nasogastric tube into the stomach

A) Organoaxial Volvulus

- The stomach rotates along its long axis = "Upside-down" Stomach
- The greater curvature located superiorly to the lesser curvature

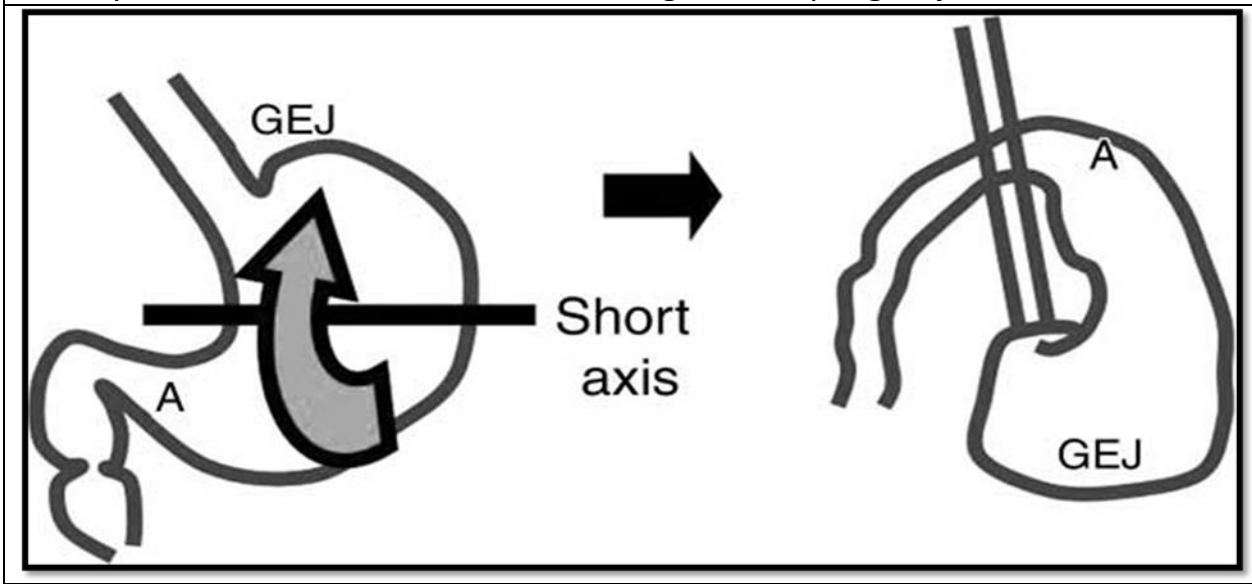


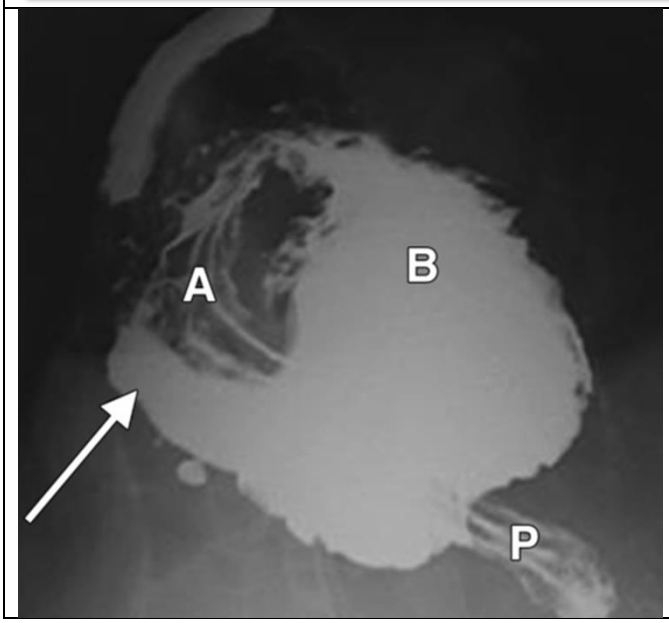




B) Mesenteroaxial Volvulus:

- Less common than organoaxial volvulus.
- The stomach rotates along its short axis.
- Displacement of the antrum above the gastroesophageal junction.



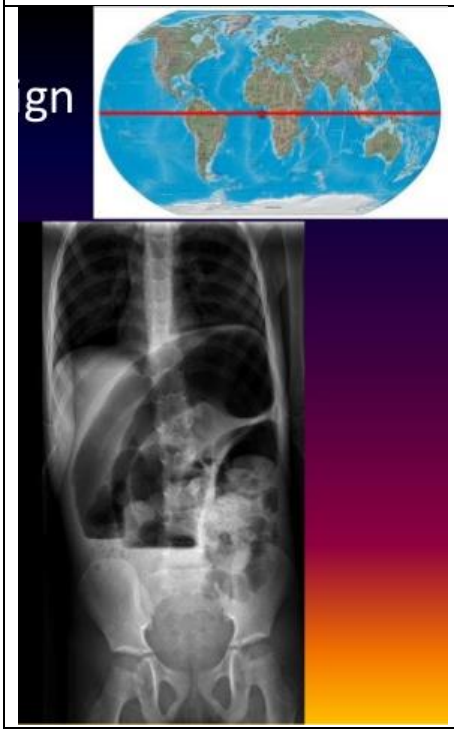


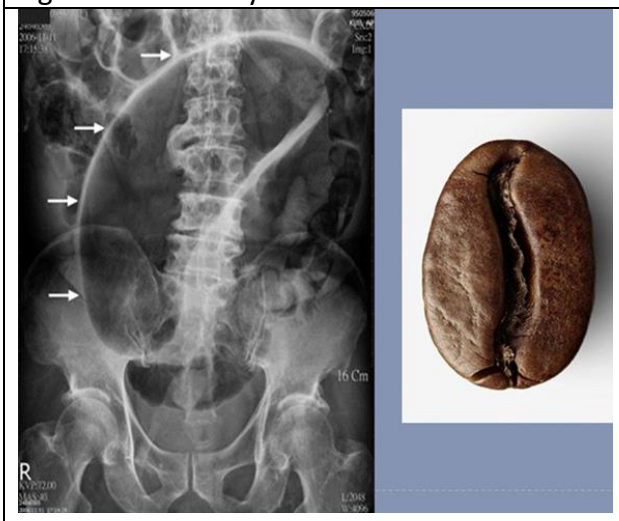
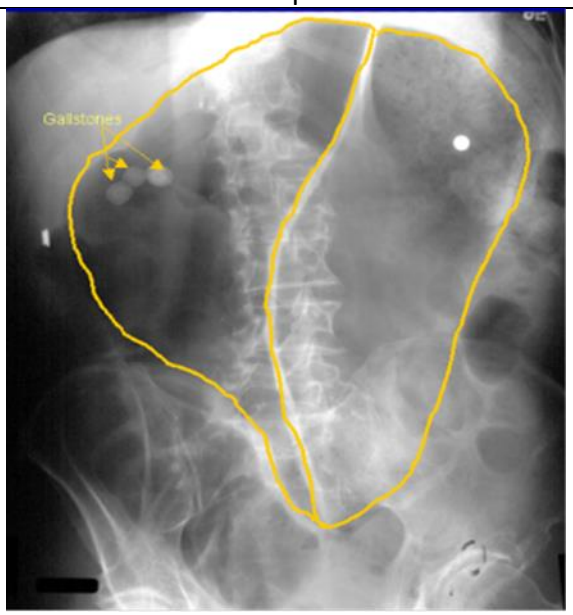
2) Sigmoid Colon Volvulus

- The sigmoid is the most common site of colonic volvulus
- It accounts for 60%–75% of all cases of colonic volvulus.

Predisposing Factors:

- It is generally considered to be an acquired condition because its prevalence increases among those with chronic constipation
- Sigmoid colonic redundancy due to a high fiber diet, pregnancy, hospitalization or institutionalization, or Chagas disease.

Northern exposure" sign:	Whirl Sign
A large air-filled bowel loop, which represents the sigmoid colon, arising from the pelvis and extending cranially beyond the level of the transverse colon	Coronal CT image shows the whirl sign
	

The “coffee bean” sign:	Beak sign:
The coffee bean–like shape that the dilated sigmoid colon may assume.	Barium enema shows abrupt termination of the contrast material column in a beaklike point
	
White-stripe Sign	**Three-line sign**
The interposed loops produce the white-stripe sign (arrow).	The obliquely oriented vertical white lines that represent the opposed walls of the dilated bowel loop (the center line) and the outer walls of the bowel loop on either side
	

3) Cecal Volvulus

- 25%–40% of all cases of colonic volvulus.
- Cecal volvulus usually occurs in patients who are much younger (typically 30–60 years of age) than those affected by sigmoid volvulus.

Predisposing Factors:

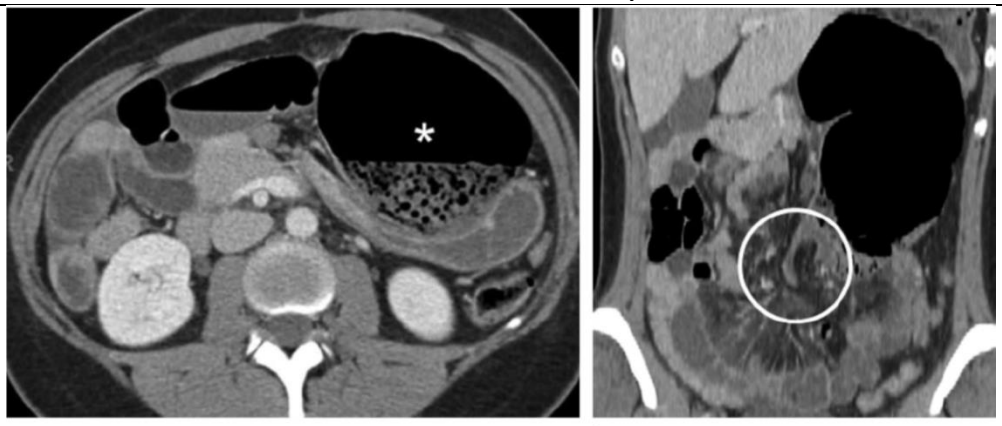
- Congenital anomalies of colonic fixation usually are present and include an abnormal fixation of the right colon to the retroperitoneum and abnormal motility of the right colon.
- Factors that result in dilatation of the right colon, such as pregnancy and recent colonoscopy, are less common and also may predispose patients to cecal volvulus

3 Types

i. **Axial (40% of patients):** the cecum twists along the axial plane, without becoming inverted, and rotates around the long axis, with the cecum occupying the right side of the abdomen, usually the right lower quadrant
ii. **Loop (40% of patients):** the cecum twists and inverts so that the pole of the cecum occupies the left upper quadrant of the abdomen.
iii. **Cecal bascule (20% of patients):** an abnormal location of the dilated cecum and is a result of anterior folding, without torsion.

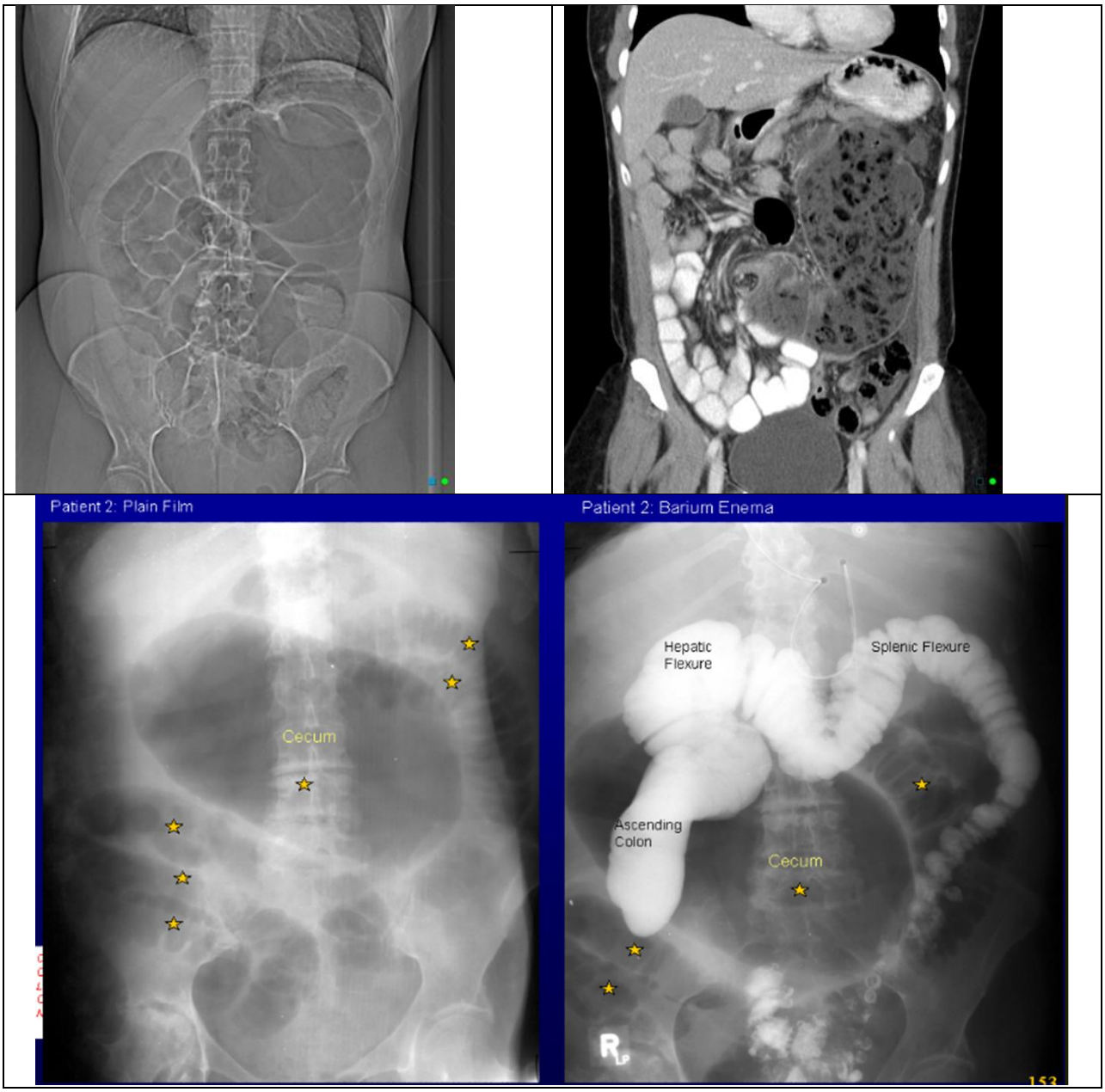
Cecal bascule

- refers to abnormal location of the dilated cecum in the mid abdomen and results from upward folding of the cecum on itself, without associated twisting.
- Cecal bascule occurs when the cecum is loosely attached to its mesentery.



a. b.

Figure 16. Cecal volvulus. Axial **(a)** and coronal **(b)** reformatted CT images show the distended cecum in the left upper quadrant of the abdomen (* in **a**). The mesenteric twist, which in this case involves the terminal ileum, is most easily seen within the circled area in **b**.


Patient 2: Plain Film
Cecum
Patient 2: Barium Enema
Hepatic Flexure
Splenic Flexure
Ascending Colon
Cecum

4) Transverse Colon Volvulus

- The transverse colon is the rarest site of colonic volvulus (<5%–10% of cases)
- But it is associated with the highest mortality

- A whirl sign adjacent to the transverse colon (arrow).

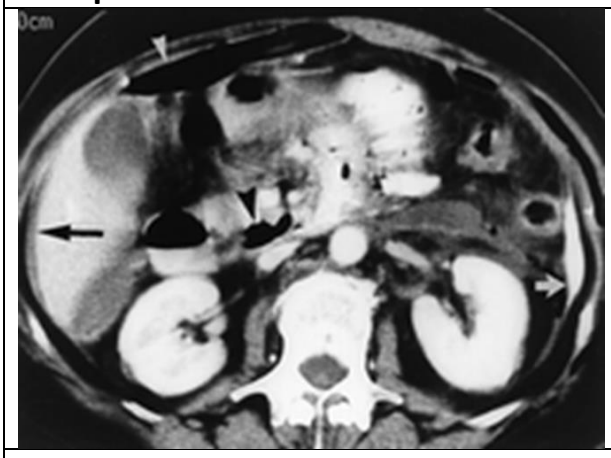
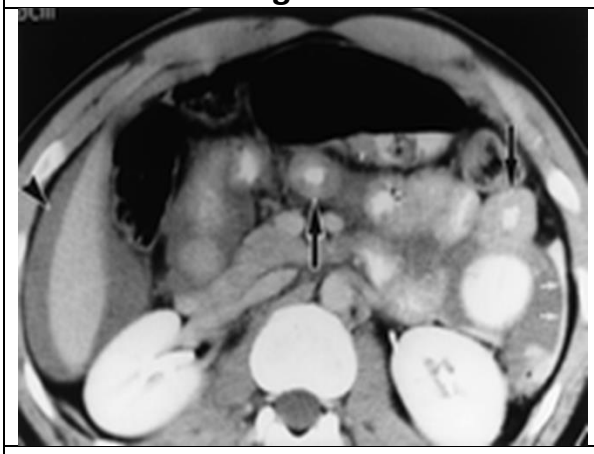
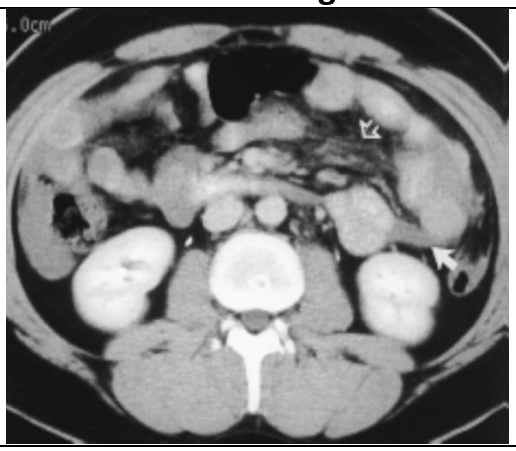
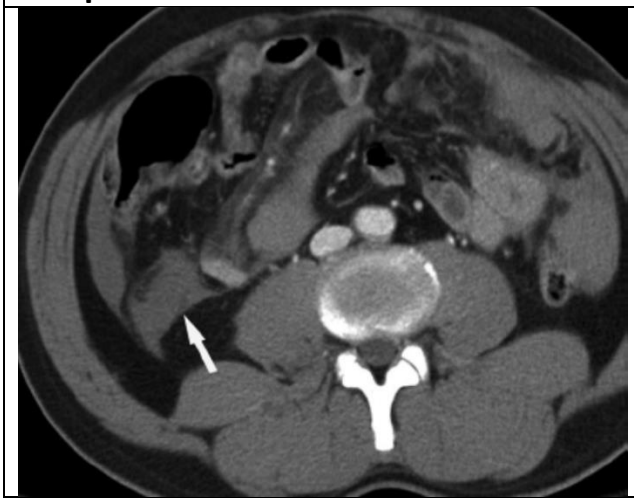
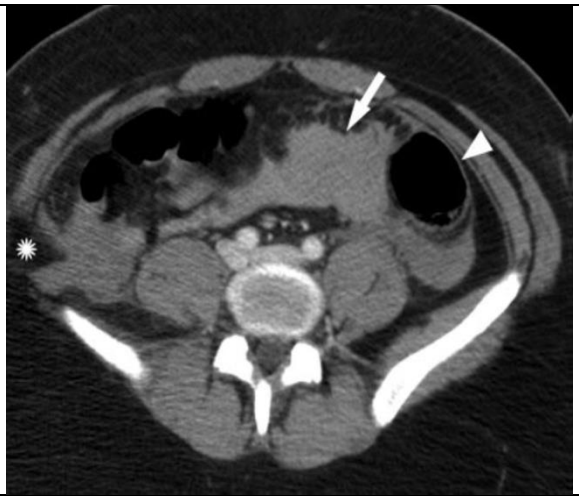
Bowel and Mesenteric Injury

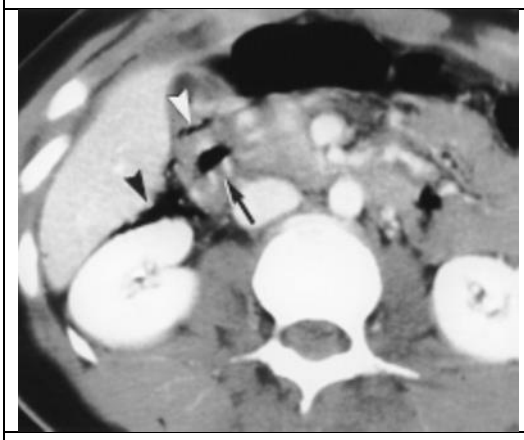
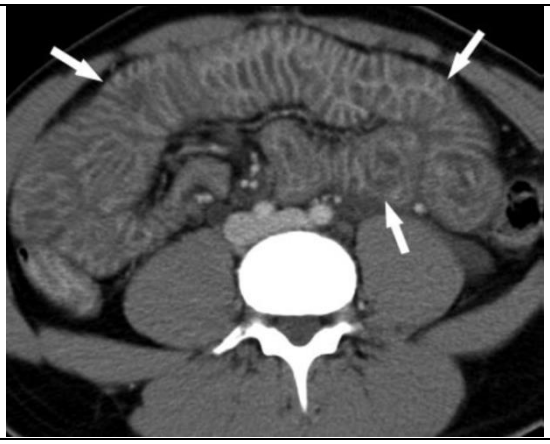
- Result from both blunt and penetrating trauma.

Role of Imaging Modalities:

- Plain radiograms are useful for evaluating pneumo-peritonium.
- FAST could detect intra-abdominal collections.
- CT is the tool of choice in evaluating BMI.
- Angiography can be used to detect intra-mesentric hemorrhage.

CT Signs of Penetrating Bowel Injury
Direct
Bowel wall discontinuity
Wound tract extending to the bowel
Leakage of oral or rectal contrast material
Mesenteric fat stranding adjacent or close to bowel loops
Active mesenteric vascular extravasation of contrast material
Indirect
Mesenteric hematoma
Interloop fluid

Intraperitoneal Air	Intraperitoneal CM
	
Bowel Thickening	**Mesenteric stranding**
	
Retrperitoneal Hematoma	**Mesenteric Hematoma**
	

Duodenal Perforation	**Jejunal Perforation**
Thick-walled duodenum (arrow), outlined by extraluminal retroperitoneal air (arrowheads).	Hypervascular thickened jejunum with a suspicious defect (curved arrow) and with focal fluid, fat stranding, Extraluminal air (straight arrow) adjacent to jejunal loops.
	
Shock Bowel	
Severe head trauma from a motor vehicle accident. Axial CT image shows hypervascular thickened jejunal loops with mucosal feathering (arrows), features characteristic of shock bowel.	

Pelvic Floor

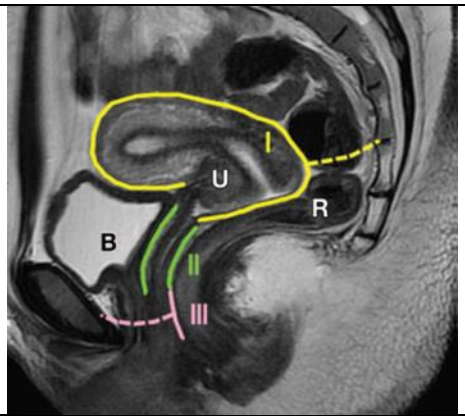
❖Pelvic Floor Anatomy:

- **Passive fasciae:**
  - **Endopelvic fascia**
  - **Perineal body**
- **Active support muscles:**
  - **Levator ani**
  - **Coccygeus muscles**

Endopelvic Fascia

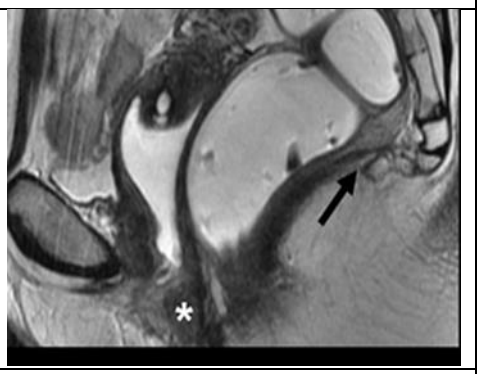
- is a layer of connective tissue that attaches the uterus and vagina to the pelvic side walls.
- Its anterior aspect, the pubocervical fascia, extends from the anterior vaginal wall to the pubis and supports the bladder.
- A tear in the anterior portion of the endopelvic fascia (pubocervical fascia) results in bladder descent or a cystocele
- A tear in the posterior aspect (rectovaginal fascia) results in an anterior rectocele or enterocele .

- Level I (solid yellow outline) suspends the uterus and upper vagina to the uterosacral ligaments and pelvic sidewalls.
- Level II (curved green lines) suspends the posterior bladder wall and middle vagina.
- Level III (curved solid pink line) suspends the urethra and lower vagina.
- The lower anterior vaginal wall and lower posterior urethral wall are fused without intervening fasciae.
- The uterosacral ligaments (dashed yellow line)



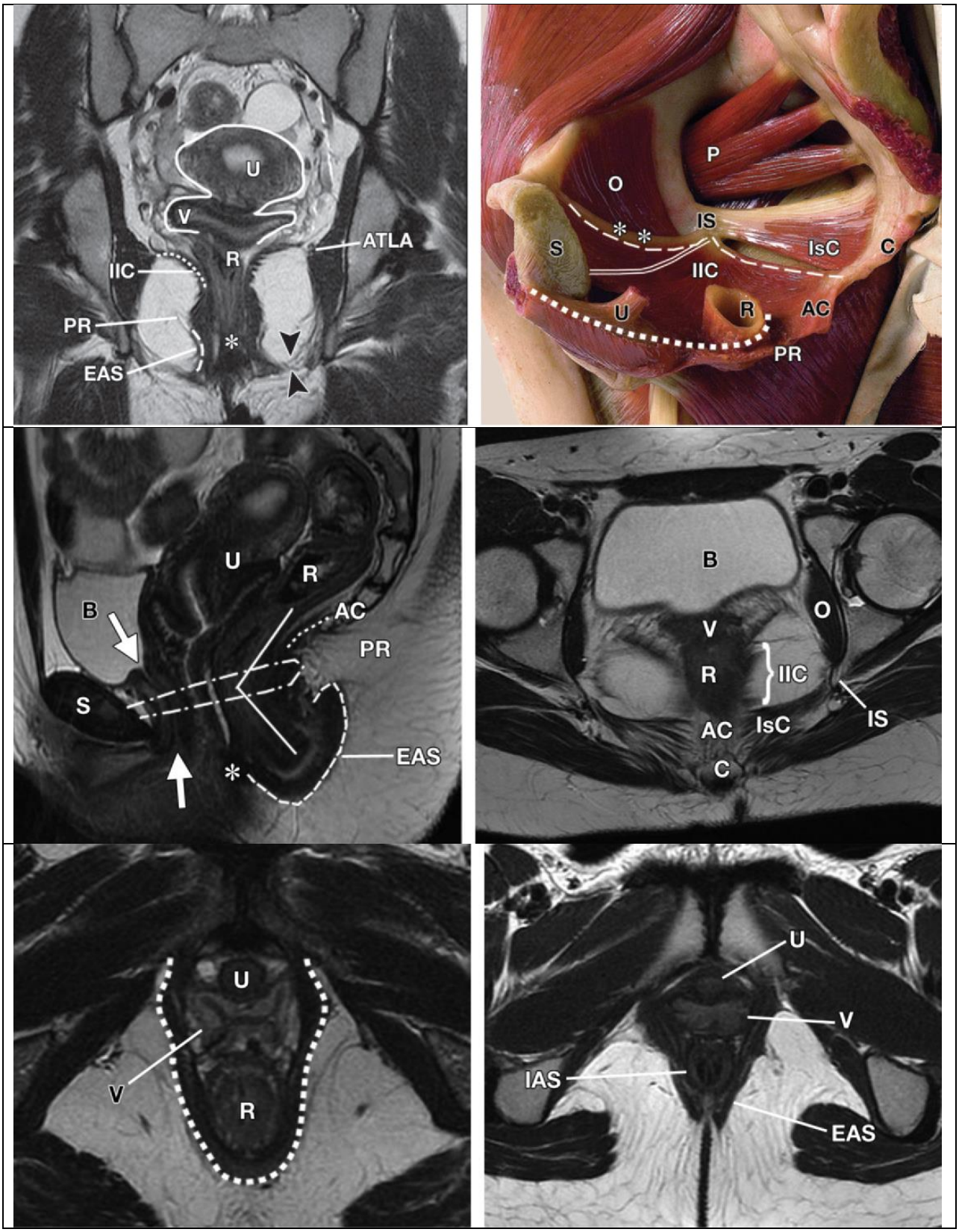
Perineal Body:

- The central tendon of the perineum
- Located between the vaginal introitus and anal canal.
- Passive structure
- into which many structures insert:
  - The external anal sphincter
  - The endopelvic fascia
  - The deep and superficial transverse muscles of perineum (urogenital diaphragm)
  - The puborectalis muscle



Levator Ani: 3 different muscle groups:

- Ileococcygeus
- Pubococcygeus
- Puborectalis muscles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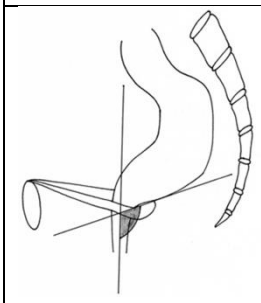
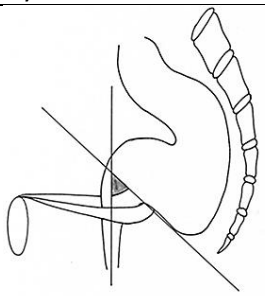
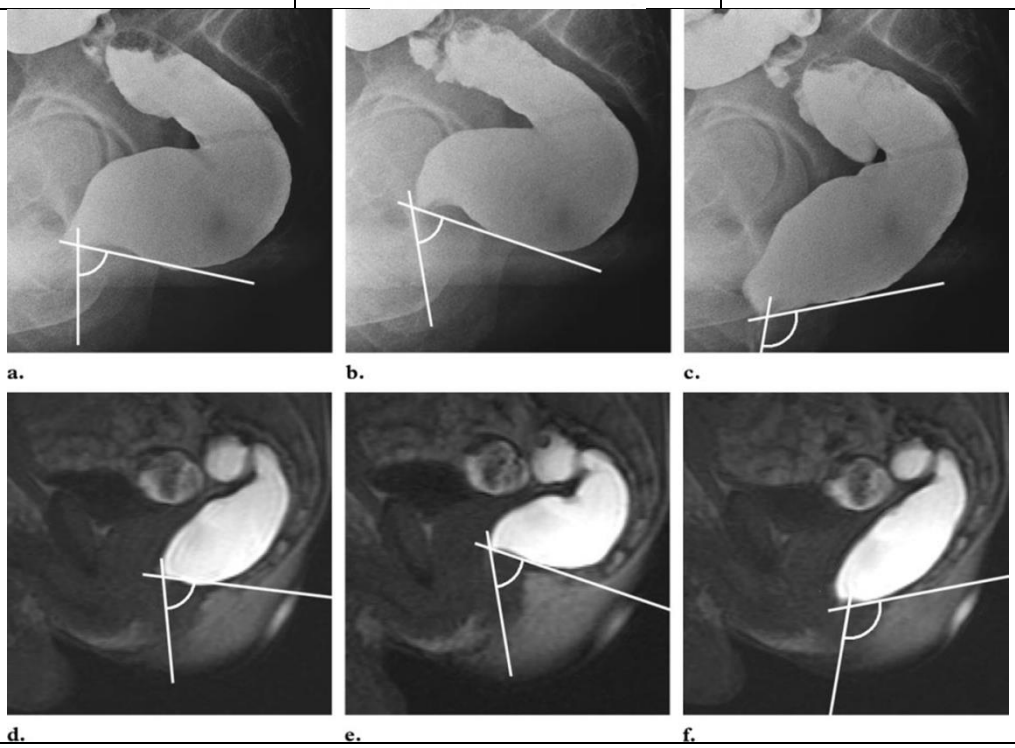
Anorectal Junction:

- The point of taper of the distal part of the rectum as it meets the anal canal
- Corresponding to posterior impression of transition between puborectal muscle and levator plate.
- Represents the point of reference for posterior compartment descent

Anorectal Angle

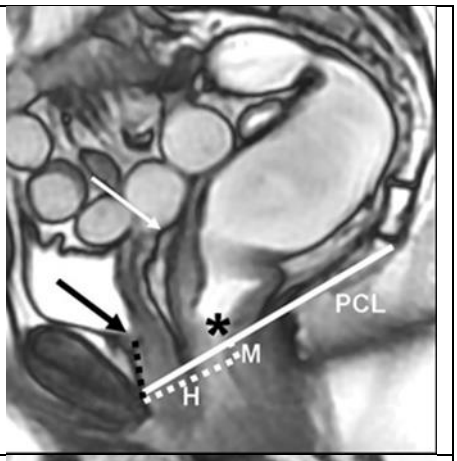
- Angle between two lines:
  - Posterior wall of the distal part of the rectum
  - Central axis of the anal canal

Rest	Squeezing	Straining and defecation
Normally measures between 108° and 127° at rest	The angle :more acute Contraction of the puborectalis muscle, which shortens and brings the anorectal junction higher and nearer to pubic symphysis	The angle more obtuse opens about 15°–20 Relaxation of the puborectalis muscle.
		



Pubococcygeal Line (PCL)

- From the inferior border of the pubic symphysis
- To the last coccygeal joint
- PCL = level of the pelvic floor
- Landmark for measuring organ prolapse

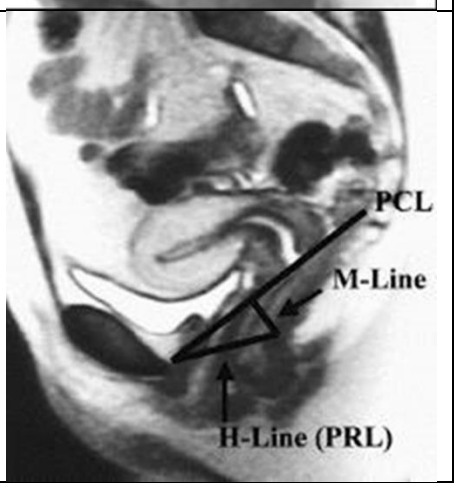


H line

- from the inferior border of the pubic symphysis
- to the posterior wall of the rectum at the level of the anorectal junction
- Normally, H lines should not exceed 5 cm in length

M line

- Drawn perpendicularly from the PCL to the most posterior aspect of the H line.
- represents the vertical descent of the levator hiatus
- M lines should not exceed 2 cm in length.



- The distance from the PCL to
  - Bladder neck,
  - Cervix
  - Anorectal junction,
- should be measured on images obtained when the patient is at rest and during maximal pelvic strain
- => All remain at or above PCL line

Pelvic Floor Dysfunction / Failure

Clinical Symptoms

- Urinary tract symptoms (stress and urge incontinence, straining to void, and positional voiding maneuvers)
- Sexual symptoms (difficult intercourse and dyspareunia)
- Bowel symptoms (fecal incontinence, difficult defecation, and rectal prolapse).
- General symptoms include pelvic pain and discomfort

- Primarily affect adult women
- 15% of multiparous women

Risk factors:

- Female sex, Menopause, Advanced age, obesity, Pregnancy, Parity
- Altered collagen metabolism
- Chronic straining due to constipation or chronic obstructive pulmonary disease may cause repetitive trauma to the pudendal nerve and lead to pudendal neuropathy

Evaluation of women with pelvic floor failure:

- Clinical assessment (physical, neurologic, and digital rectal examination)
- Physiologic testing (urodynamic, anorectal manometry, and electromyography)
- Imaging (Conventional proctography, static and dynamic MRI)
    - Anatomic analysis of the damage on axial T2 FSE
    - Functional evaluation using sagittal dynamic SSFSE T2 during straining and defecation.

❖ MR Imaging Technique

- Patient position:
  - Supine in a closed-magnet system
  - Sitting in an open-magnet system.
- Patient preparation
  - No oral or intravenous contrast agent is administered.
  - Cleansing rectal enema (using warm water) the night before the MR examination.
  - Rectal filling is mandatory :200 ml of sonographic gel
  - Bladder filling: bladder is distended.
  - Vagina: is filled with 5 ml of sonographic gel

Static MRI:

- A rapid a midline sagittal scout images :the symphysis, bladder neck, vagina, rectum, and coccyx.
- Axial, sagittal, and coronal T2 thin-section sequences

Dynamic MRI

- using a steady-state sequence
  - FIESTA [fast imaging employing steady-state acquisition],
  - True FISP [fast imaging with steady-state precession],
  - Balanced FFE [fast field echo])
- Midsagittal SSFSE MR plane at rest, straining, and defecation.

Dynamic (cine) images:

- In each plane 5 slices during 6 phases are acquired; each phase takes 10 s. These 6 phases are acquired
  1) At rest
  2) Contraction of the pelvic
  3) Mild straining
  4) Moderate straining
  5) Maximum straining
  6) Repeated maximum straining sequence to ensure maximal valsalva maneuver

Prolapse severity can be easily graded according to the "rule of 3":

Prolapse of an organ below the PCL by

Mild =< 3 cm
Moderate 3 - 6 cm
Severe > 6 cm

A- Anterior Compartment Abnormalities

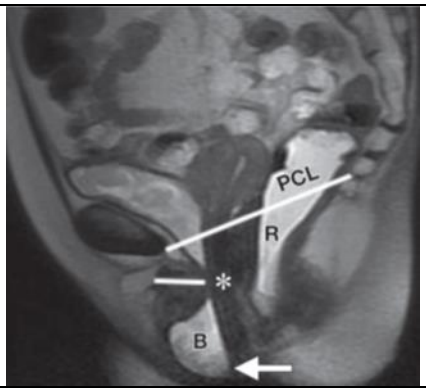
1) Cystocele

- Bladder base descent below the border of the pubic symphysis.
- Occur tearing or stretching of the pubocervical fascia.
- Develop in the menopausal period

Bladder base below the PCL:

- Small : >1cm and < 3 cm
- Moderate : 3 - 6 cm
- Large : > 6 cm

H-line > 5 cm
M- line > 2 cm



2) Stress Urinary Incontinence

Stress urinary incontinence is caused by:

- Urethral hypermobility (80%–90%):
  - Laxity of urethral supporting structures (due to vaginal delivery, hysterectomy, or menopause) that leads to rotation of the urethral axis from vertical to horizontal, to a position more than 30° from its resting axis, during straining (termed rotational descent)
- Intrinsic sphincter dysfunction (10%–20%) with or without funneling

Urethral funneling:

- Dilation of the proximal urethral lumen
- Shortening of the urethra
- This finding may indicate intrinsic urethral sphincter incompetence in incontinent women

B-Middle Compartment Abnormalities

❖ Uterine Or Vaginal Vault Prolapse:

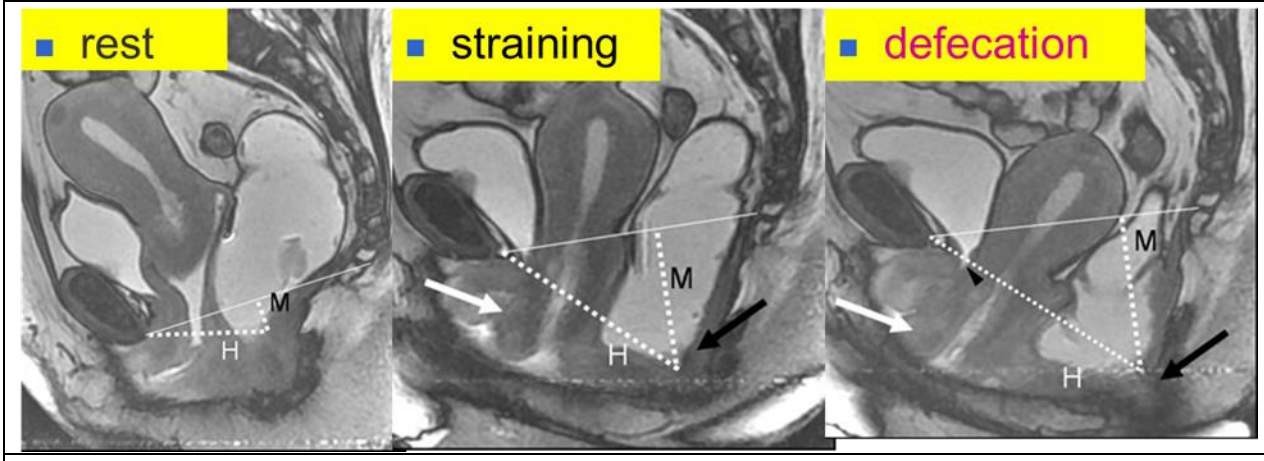
Uterine and vaginal support structures :-

- Uterosacral ligaments (which suspend uterus and upper vagina from the presacral fascia)
- Pubocervical fascia (which attaches the lateral part of the vagina to the pelvic sidewalls)
- Rectovaginal fascia (which attaches the posterior part of the vagina to perineal body).

A paravaginal fascia defect can be suspected when the vagina loses its “H” shape on axial images

Descent of the vaginal vault or cervix below the PCL

- Mild if the vaginal vault or cervix extends < 3 cm below the PCL
- Moderate between 3 and 6 cm
- Severe > 6 cm below the PCL



During straining and defecation:

- The uterus moves downward inside the vagina and the cervix exits the vaginal introitus (white arrow).
- H and M lines are abnormally elongated.
- The vagina appears shortened and everted
- Urethral funnelling without hypermobility (arrowhead)
- Severe (7 cm) posterior compartment descent (black arrow) are also seen.

C- Posterior Compartment Abnormalities

1) Rectocele

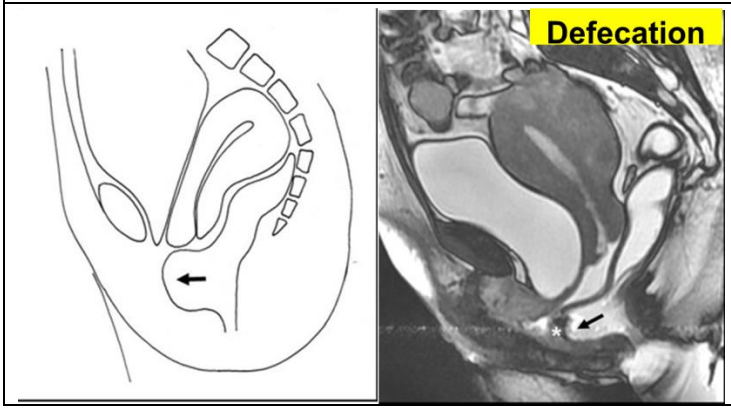
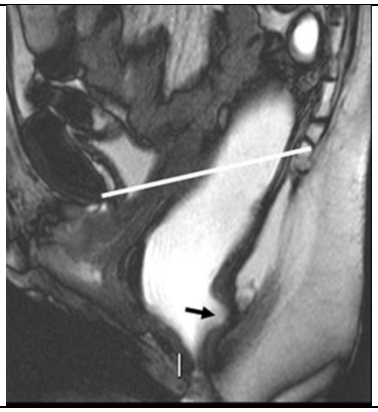
- Abnormal bulging of the rectal wall due to inadequate support and laxity of the endopelvic fascia above the anal canal
- Anterior wall >>>> posteriorly
- Measured as the depth of wall protrusion beyond the expected margin of the normal anorectal wall, and they are clinically significant when the bulge > 2 cm during evacuation
- < 2cm Small 2-4 Moderate > 4cm Large
- Anterior rectoceles can stretch the perineal body and bulge into the vagina

Identified risk factors of developing a rectocele :

- Vaginal delivery trauma
- Constipation with chronically increased intraabdominal pressure
- Hysterectomy
- Aging

MR defecography provides information about :

- The size
- Dynamics of rectocele emptying,
- Retention of contrast medium within the rectocele,
- Coexistent abnormalities.

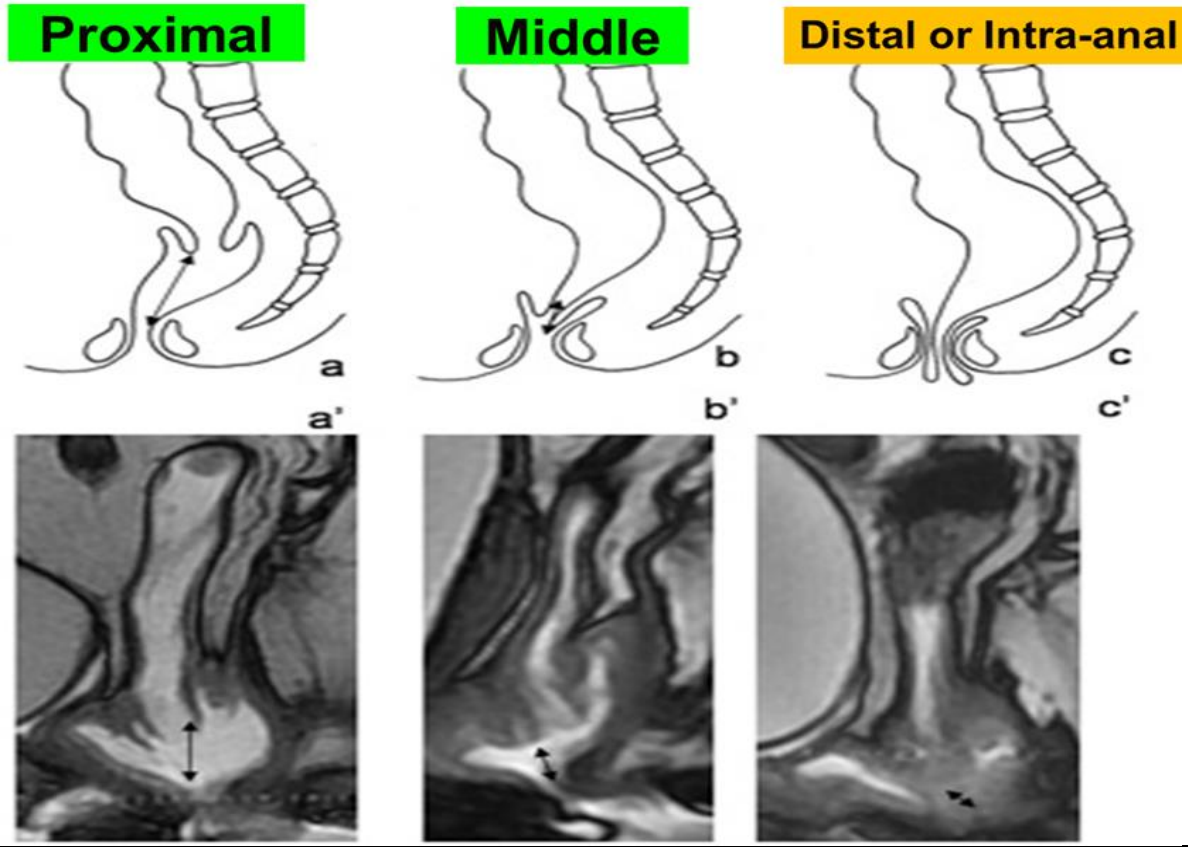
Anterior Rectocele	Posterior Rectocele
	

2) Rectal invagination and prolapse

- Rectal invagination or intussusception, is defined as a full-thickness rectal wall prolapse involving both the mucosa and muscular layer
- This causes a mechanical obstruction to the passage of stool.

Classification of intrarectal intussusception:

- Intrarectal (distal, middle, or proximal with respect to rectal length)
- Intraanal, or extraanal



Extraanal invagination :- clinically termed rectal prolapse

- Low-grade intussusception:- rectal mucosa infolding but not entering the anal canal
- high-grade intussusception :- full-thickness prolapse that penetrates the anal canal or impedes evacuation.

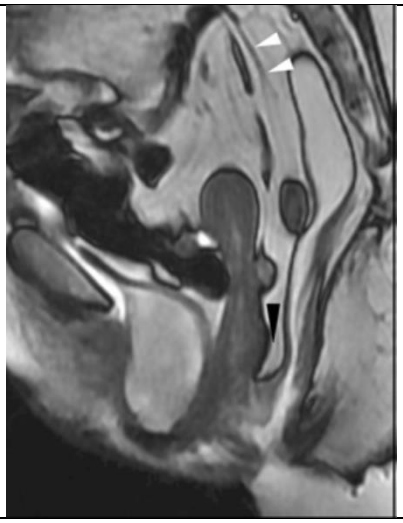
3) Enterocele

- A herniation of the pelvic peritoneal sac into the rectogenital space, the rectovaginal septum in women, passing below the proximal 1/3 of the vagina.
- It may contain
    - Fat, called peritoneocele
    - Small bowel or sigmoid colon.
- Patients who have undergone hysterectomy
- Enterocele usually occurs at the end of evacuation
- Enteroceles are graded small, moderate, or large if they extend 3 cm, 3–6 cm, or more than 6 cm, respectively, below the PCL.

MR imaging criteria for enterocele diagnosis

- The presence of bowel between the vagina and rectum,
- bowel below the PCL,
- Widening of the rectovaginal space,
- Abnormal deepening of the cul-de-sac.

- A spontaneous irreducible enterocele = perineal hernia
- An enterocele may result in compression of the distal part of the anorectum and finally in incomplete evacuation due to outlet obstruction
- The feeling of incomplete evacuation might be caused by bowel loops resting on the sigmoid colon and lead to repetitive and unproducting straining
- Stretching or tearing of the mesentery can also cause pain in the lower abdomen or back .

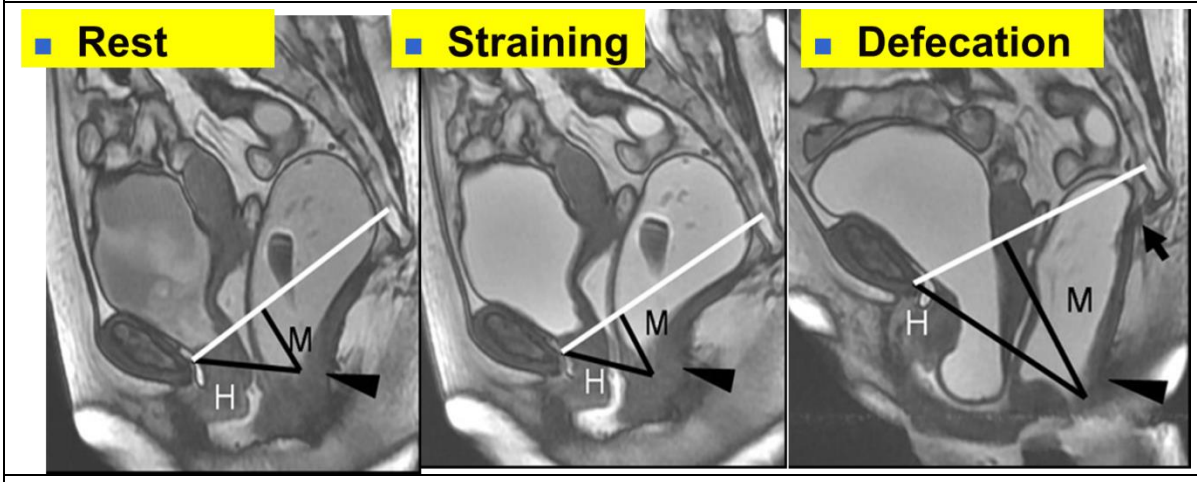


❖ Descending Perineal Syndrome:

- The pelvic muscles lose tone, resulting in excessive descent of the entire pelvic floor at rest or during evacuation
- Underlying causes:-
    - Pudendal nerve injury, due to delivery trauma or neuropathy,
    - Chronic straining at defecation.
- Patients may have a dysfunction affecting the perineal body or levator ani musculature, so that diffuse bulging or focal asymmetry of the levator ani muscle can occur, best imaged in the coronal plane.

Dynamic MRI images:

- perineal descent can be quantified by measuring the descent of the anorectal junction from the PCL, considered abnormal if exceeding 2.5 cm
- H and M lines will be longer
- A caudal angulation of the levator plate will also be evident
- a decreased elevation of the pelvic floor at maximal contraction can be observed
- This syndrome can involve not only the posterior but, frequently, the anterior and middle compartments.
- Associated with a feeling of incomplete evacuation, which leads to increased straining during evacuation and consequent additional neuropathic injury that may result in incontinence.



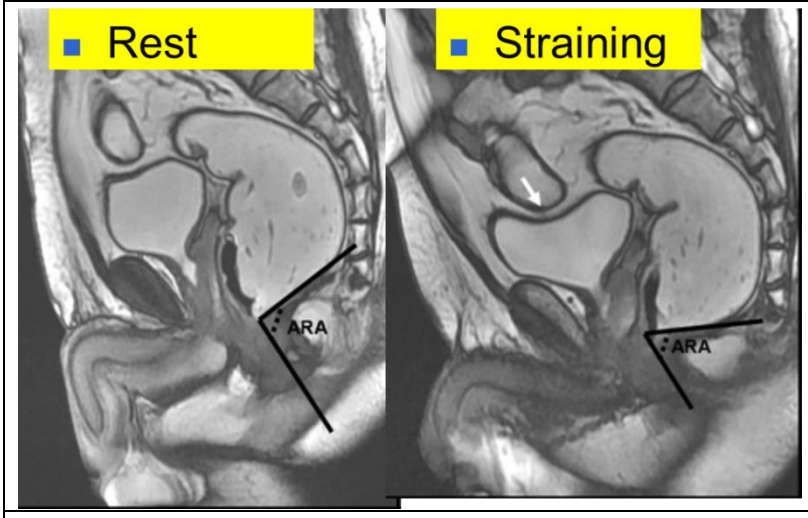
Severe three-compartment descent in a 62-year-old woman.
(a) At rest, the bladder and uterus are in the correct positions with respect to the PCL (white line), while the anorectal junction (arrowhead) is abnormally below the PCL, with elongation of the H and M lines.
(b) During squeezing, the anorectal junction (arrowhead) fails to rise with respect to the PCL.
(c) At defecation, the bladder base, cervix and anorectal junction are abnormally below the PCL. The H and M lines are abnormally elongated, and the levator plate is directed vertically (arrow

❖ Spastic pelvic floor syndrome
Pelvic floor Uncoordination or Anismus.

- a functional abnormality that affects some constipated patients who experience evacuation failure associated with involuntary, inappropriate, and paradoxical contraction of striated pelvic floor musculature
- The etiology of this condition is unclear, may be
    - Abnormal muscle activity
    - Psychologic or cognitive factors
- Increased pressure at rest and during defecation is shown with anorectal manometry, while pathologic signals at EMG

Dynamic MRI images:

- Lack of descent of the pelvic floor during defecation
- Paradoxical contraction of the puborectalis muscle with failure of anorectal angle to open
- Thus resulting in prolonged or incomplete evacuation.
- Puborectalis muscle is frequently hypertrophic and makes a prominent impression on the posterior rectal wall during voiding
- A long interval between opening of the anal canal and start of defecation
- An anterior rectocele below the contracted puborectalis muscle can also be associated with this syndrome



At strain

- The anorectal angle (ARA) paradoxically closes and the anal sphincter fails to open, due to inappropriate contraction of the puborectalis muscle, which conforms to spastic pelvic floor syndrome.
- Note the small bowel loops pushing on the bladder roof in b (arrow) owing to increased intraabdominal pressure during the Valsalva maneuver

❖ Anal Incontinence

- Is common, especially in women, with a prevalence increasing with age, and has a considerable economic impact
- Present with either
- Fecal leakage they are unaware of, = an internal sphincter abnormality
- With urge incontinence = external sphincter damage.
- Most common cause of incontinence is vaginal delivery that causes direct sphincter laceration or indirect damage to sphincter innervation.
- Other causes include iatrogenic damage (as a complication of anal surgery) or neuropathy.

Imaging of fecal incontinence relies on:-

- Endoanal MR imaging
- Ultrasonography of the anal sphincter,
- Anal canal manometry is also important for determining whether sphincter function is normal, although it is unable to help differentiate traumatic damage from atrophy
- The aim : detecting sphincter tear or atrophy and thus selecting patients likely to benefit from surgical repair

MR defecography findings:-

- Inability to hold an enema,
- Anorectal angle changes of less than 10°
- Pelvic floor descent
- Intussusception
- Rectocele

A. Location and type of prolapse:

1. Anterior compartment:
   a. Bladder neck descent; grade: _____
   b. Bladder base descent; grade: _____

2. Middle compartment:
   a. Uterine descent; grade: _____
   b. Enterocele/peritoneocele; grade: _____

3. Posterior compartment:
   a. Anorectal junction descent; grade: _____
   b. Rectocele; grade: _____

B. Defects in the pelvic supporting system:

1. Urethral supporting structures:
   a. Ligament(s); type of injury: _____; side: _____
   b. Fascia level III:
   c. Puborectalis; type of injury: _____; side: _____

2. Vaginal supporting structures:
   a. Vaginal fascia level I and II; side: _____
   b. Iliococcygeus; type of injury: _____; side: _____

C. Anal sphincter:

a. External anal sphincter; level of injury: _____; site: _____; type of injury: _____
b. Internal anal sphincter; level of injury: _____; site: _____; type of injury: _____

D. Measurements of supporting structures :

H-Line: _____; M-line: _____; levator plate angle: _____
Width of levator hiatus: _____
Iliococcygeus angle: _____

Opinion

The predominant defect(s) is(are): _____
Ligaments: _____
Fascia: _____
Muscles injury and/or weakness: _____